DEPARTMENT OF AGRICULTURE.
CHEMICAL DIVISION.
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THE

RTHERN SUGAR INDUSTRY.

A RECORD OF ITS PROGRESS

DURING THE

SEASON OF 1883.

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DEPARTMENT OF AGRICULTURE.
CHEMICAL DIVISION.
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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
CHEMICAL DIVISION,
Washington, D. C., April 22, 1884.

SIR: I have the honor to submit herewith a report on the results of my investigations of "The Northern Sugar Industry."

This report contains the work of this division during the past year on sorghum and sugar beets, and such other reliable data on the same subjects as could be collected from different parts of the country.

Respectfully,
H. W. WILEY,
Chemist.

Hon. GEORGE B. LORING,
Commissioner.

THE NORTHERN SUGAR INDUSTRY.

It has been nearly thirty years since the introduction of the sorghum plant into this country.

Under ordinary conditions this would have been ample time to determine whether it could be used with success as a sugar-producing plant. But unfortunately the methods of investigation which have been practised have been disjointed and desultory.

It is true that a great deal of valuable work has been accomplished. Many investigators have employed their time and patience in solving some of the many problems which envelop and confuse the question.

I should feel that I had neglected my duty were I to refuse to these able and industrious men due praise for the value and excellence of their work. In spite of all this, however, the interesting fact remains "that after thirty years of work the total amount of sugar made from sorghum cane during the past year was not quite one million pounds."

The sorghum problem presents itself under two distinct heads, viz., *scientific* and *economic*.

To the pure scientist the question is only one of constitution and best method of determining it. To the pure economist, on the other hand, the question is one of finances and the best method of making money out of the investment.

A fair discussion of the subject must embrace both of these points. But since the work of my division has been purely experimental, this report will deal chiefly with the first.

The sorghum cane is known in this country under a great variety of names, but botanically these all belong to the same species.

Among the hundreds of sugar-producing plants only four are practically employed for sugar production, viz., the maple, the tropical cane, the sugar beet, and sorghum.

The tropical cane is the richest in sugar of all these.

The maple and sugar beet are best suited to high temperate latitudes, while the sorghum seems destined to claim the middle temperate zone for its own peculiar field.

It has, however, certain varieties, like the Amber, which reach maturity in a wonderfully short time for a sugar-producing plant. I do not doubt but that by wise and careful selection the time required for ripening may be materially shortened.

It thus appears that the belt of country suitable to sorghum culture may become quite a wide one. It should be remembered, however, that this belt should be bordered by lines of isothermacy and not by parallels of latitude.

In discussing the geographical limits of sorghum culture it has been usual to say that they are the same as for maize. This is both true and false—true in that the early varieties of sorghum will grow as far north as our corn, and the late ones as far south; false in the assumption that the mere growing of sorghum is enough to insure success in making sugar from it. Not only must there be time for growth but also for manufacture. The effect of cold weather on sorghum cane may be summarized as follows:

(1.) A frost severe enough to kill the blades of immature cane will spoil it for sugar-making.

(2.) Such a frost on ripe cane will not do it any notable injury.

(3.) A frost severe enough to congeal the water in the cells of the cane will render it unfit for sugar-making immediately on the accession of thawing weather. To determine the length of the working season, therefore, is to know (1) the time of ripening of the cane, *i. e.*, when the seed is hard, and (2) the time when the first severe frost is likely to take place.

I have often seen it stated that Early Amber cane in the North ripened its seed in 90 days, and I do not wish to place myself in the attitude of doubting these statements.

They are, however, not in harmony with my own observations. How many in latitude above 42° have ever seen whole fields of Amber cane with hard seed in 90 days after planting? Single heads, doubtless, often, but whole fields seldom. I am inclined to think, then, 100 or 110 days are more likely to be the proper time for beginning operations at the mill.

It is wrong to take a few extreme instances and make a general law from them. Such generalizations always lead to harm and often cause the innocent to suffer. I will not try to fix the other limit of the working season, *i. e.*, the time of the first freezing of the cells. In the latitude of Chicago it will probably be found not far from the middle of October, taking a series of years into calculation. Thus, I find the working season in these latitudes limited to four or six weeks, and this is a point which must be taken carefully into consideration.

In length of working season the beet appears to have a great advantage over sorghum. As is well known, the beet is harvested before any freezing weather and put in silos. Here it is kept during the winter months, or until it is sent to the mill. If the temperature of the silos is kept low enough the beets will retain their sugar until the following spring. Beet-sugar factories in Europe sometimes keep running until March or April.

The advantage of keeping the machinery in use for as long a time as possible is one which will be keenly appreciated by every manufacturer. The cost of a sugar-factory plant is very great. Machinery is injured more by idleness than by use. The shortness of the working season, therefore, becomes a difficulty the most serious to the success of the sorghum business.

Is it possible to preserve cane in a silo in the same manner as beets? I have tried to answer this question by a simple experiment. On the 12th of November, 1883, I put one ton of sorghum canes in a pit on the grounds of the Department of Agriculture, in Washington. The pit was made by digging a shallow ditch. The canes were placed in this and covered with earth.

Numerous analyses of juices of canes similar to those preserved showed sucrose (about) 9 per cent.; other sugars (about) 3 per cent.

On the 19th of November a deep-soil thermometer was placed in the silo, so that its bulb was in the midst of the canes. This was done to compare internal and external temperatures, and detect any tendency to "heating" which the canes might show. Daily observations were taken of the two thermometers until December 12, on the night of which, unfortunately, the instrument was stolen. Following are the results of those observations:

Comparison of internal and external thermometers in sorghum silo from November 19 *to December* 12, *inclusive.*

[Time, 10 a. m.]

Date.	Internal thermometer.	External thermometer.	Condition of weather.
	°Fahr.	°Fahr.	
Nov. 19	38.5	41	Rainy.
20	38.5	56	Do.
21	38.5	Not taken.	Do.
22	46	66	Very warm and cloudy.
23	52	65	Do.
24	57	59	Cloudy.
25	59	50	Do.
26	58	48	Rain.
27	57	42	Fair.
28	54	43	Do.
29	50	37.3	Do.
30	47	42.7	Do.
Dec. 1	47	39	Do.
2	46.5	50	Do.
3	46	35.3	Do.
4	44	40	Do.
5	43	48.5	Do.
6	44.5	44.9	Do.
7	44.25	42.2	Cloudy.
8	46	....	Do.
10	46	46.5	Fair.
11	46	43.6	Do.
12	45	45.9	Cloudy.

I think it is highly important that the temperature of the silo should not rise above 50° F.

The week of warm weather beginning on the second day after the commencement of the observations brought the temperature of the silo to a maximum of 59° F.; but this was not reached until three days after the maximum of the external thermometer. In all cases the changes of temperature in the silo were gradual as compared with those of the external thermometer. This slowness of change of temperature is essential to the preservation of the sucrose in the juice.

On the 14th of January, 1884, the ground being then frozen, the silo was opened and a bundle of canes taken out. Following are the results of the examination:

ANALYSIS OF CANE FROM SILO JANUARY 14, 1884.

Percentage of juice expressed	68.9
Specific gravity, 8° B =	1.057
Percentage of sucrose	8.39
Percentage of other sugars	2.36

The next analysis of the cane from the silo was made February 27, 1884. At this time the winter was practically over, and the results of this analysis show that the cane had been kept with a loss of only a small portion of its sucrose.

ANALYSIS OF CANE FROM SILO FEBRUARY 27, 1884.

Percentage of juice expressed	73.67
Specific gravity	1.057
Percentage of sucrose	7.00
Percentage of other sugars	3.13

These experiments are interesting in that they show the possibility of preserving canes in this way. It is, however, a question of practical importance to know if such a method of preservation would be useful in preserving cane for manufacturing purposes. This question, however, could only be answered by conducting the experiment on a large scale in connection with a sugar factory. I shall also try planting some of these canes in the spring, and notice the character of the crop which grows from them.*

Since undertaking the above experiment I have learned that sorghum is preserved in silos in Japan. Following is a report of Consul-General Van Buren on this subject:

> The sugar of Japan is made from that species of the sorghum plant known as the Chinese sorghum. It grows luxuriantly in all the southern portions of the Empire north of the thirty-sixth degree of north latitude.
>
> The whole product of the Empire in 1878 was 64,297,380 pounds. Importation in 1878 was 67,434,805 pounds. For three or four hundred years the processes of granulating and refining sugars have been known and practised. Sorghum is not grown, as with us, from the seed, but from cuttings. In September selected stalks are cut and buried in trenches a foot deep. Through the winter from each joint of the stalks sprouts grow. In the spring these joints are cut off and set out in rows 15 to 18 inches apart, and about the same distance from each other in the rows. The ground

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* The last examination of the siloed cane was made April 1, 1884. Results:

Weight of cane pressed, kilograms	7.53
Per centage of juice expressed	73.81
Specific gravity	1.05
Percentage of sucrose	5.89
Percentage of other sugars	3.72

The attempt to grow a crop from the joints of the preserved cones proved futile. The germs at the joints were dead, and in no case was a growth obtained.

has previously been thoroughly dug up and pulverized by a long-bladed mattock. The fertilizers used are ashes, fish, decomposed hay, straw, and sea-weed, or night soil. The plants are thoroughly hoed, hilled, and irrigated. In October and November the leaves are stripped off and the stalks are then cut and the hard outer covering is removed, and the remaining portion is then ground between rollers of stone or hard wood. The cane juice is then boiled in iron kettles till granulation takes place, when it is placed in bags and pressed dry. The expressed sirup is used as molasses. Dry upland soils are required for the successful growth of the cane, and the expenditure of labor and fertilizers is as great, if not greater, than for any other crop. Great exertions are being made to promote the increased production of sugar, and large orders for apparatus for sugar-making came from districts which heretofore have not grown sugar-cane.

USE OF MACHINERY FOR OTHER PURPOSES.

It may be asked also, "Cannot the machinery be used to refine raw sugars and molasses or to make glucose during the part of the year when not needed for working the cane crop?" I think the answer to this question must be "No." The refining of sugar is a business of itself. The profits of the refiner are not large, and he has to work immense quantities of raw sugar in order to make money. He has also to have the advantage of the best shipping facilities. Our successful refineries are built near water transportation, on the seaboard and at Saint Louis. A sorghum factory must be far from the great centers of trade, where land and labor are cheap. From these considerations I am certainly of the opinion that refining carried on in such localities and without special facilities would only result in financial loss to the operator.

In regard to the manufacture of starch sugar, perhaps I could not do better than to refer to the manufacturers of this article themselves. In fact, it is a business which is already sadly overdone. The *furore* which attended the first years of its introduction attracted a flood of capital which finally washed away all the profits.

I think it best that the sorghum-sugar manufacturer should understand perfectly that his business is "sufficient unto itself," and that he cannot count on any lateral business to help him out which does not directly pertain to the sorghum industry.

I have thus dwelt somewhat in detail on the season as it affects this great problem, because I believe that in this one point the sorghum-growers have more occasion for careful thought than in any other one factor which they will be called on to consider.

To further illustrate the problem of climate, I present herewith illustrations of the isothermal lines,* including the region about Cape May, where the climate appears to be the most favorable to the manufacture of sorghum of any of the localities in which that business is now conducted on a large scale. I select Cape May as a point of comparison because in that locality, as illustrated by the experience of the Rio Grande factory, the seasons appear favorable both for the growth and manufacture of the crop.

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* See isothermal maps at end of report.

By taking the isotherm for each month next north of Cape May, and following it westward, a line will be traced south of which, as far as thermal conditions are concerned, the cultivation of sorghum for sugar can be carried on with reasonable hope of success. Several years of experiment, however, must be awaited before the geographical limits of successful sorghum culture can be accurately defined.

As a further contribution to the climatic literature of this problem, I give also a record, taken from the official figures of the Signal Office, of the mean temperature for each month, winter excepted, of the years 1880, 1881, 1882, and 1883, as observed at the principal stations of that office;* also, in a separate table, the mean temperature for a series of years at Cape May, N. J.; Champaign, Ill., and Dodge City, Kans. These are localities at or near which sorghum-sugar factories are already in operation.

Statement showing the mean annual temperature at Cape May, N. J.; Champaign, Ill., and Dodge City, Kans.

[Compiled from the records on file at the Signal Office.]

Station.	No. of years.	Mean annual temp.
		°
Cape May, N. J	11	53.6
Champaign, Ill	2	51.5
Dodge City, Kans	8	53.3

In order to hasten the determinations of the climatic conditions affecting sorghum culture I call attention to my report to you published in the annual for 1883:

EXPERIMENTS IN CULTIVATION.†

Equally as important as the above is the question, "*What parts of the country are most favorable to the growth of sugar-producing plants?*"

With the tropical cane this question is already answered; but with sorghum and the sugar-beet it is still undecided. Only systematic experiments, conducted under the direction of the Department of Agriculture, can give a satisfactory answer.

Following are the points which take precedence in the investigation:

1. Kind of climatic conditions.
2. Kind of soil.
3. Kind of fertilizers.
4. Varieties of cane or beet.
5. Effect on soil.

I recommend that you make arrangements with the agricultural college of each State, or other reliable institution or citizen, to carry on experiments in the directions indicated above. For this purpose it will be necessary for Congress to make an appropriation of $1,000, or other sufficient amount, to be paid by you to the proper authorities of each State or private institution undertaking the work.

At first experiments should be undertaken with a few kinds of the best approved varieties of the beet and cane. Two acres of land will be enough for each State. This should be divided into ten plats. Five of these should be planted with sorghum, four with beets, and one with Indian corn. The yield of corn will serve as a measure to

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*P.31 *et seq.*

†Annual Report Dept. Agr., 1883, page 443.

determine the productiveness of the soil and character of the season. Analyses (uniformly carried on) should be made of the soil, fertilizers, and products.

In the fall (or spring following), after the analyses are completed, the whole number of plats should be planted in wheat of a kind suitable to the locality. The yield of wheat will be a measure of the comparative effects of the different products on the fertility of the soil.

Such a series of experiments carried on under uniform conditions over the whole country would do more in five years to determine these great agricultural problems than fifty years of spasmodic and disjointed work could accomplish. I have only mentioned here the outlines of the future scope of the experiments in sugar culture, experiments in which every part of the country will take a part and feel an interest. If they become authorized by law, it will be easy to systematize and formulate all the details of the operations to be carried on.

IMPROVEMENT OF SEED.

Much of the success of the beet-sugar industry of Europe has been due to a wise selection and improvement of the seed, by which the sugar content of the beet, in some instances, has been nearly doubled. There is no reason to doubt that a similar improvement (but not, perhaps, to the same extent) could be made in northern cane.

Such an improvement station could be established at small cost; but, to be effective, must be continued through a series of years. The seed of those canes showing the highest sugar content should be planted and the selection continued until a maximum of sugar is obtained. If in this way a variety of cane could be produced which would give an average result in analysis of only 2 per cent. uncrystallizable sugar and 10 per cent. of sucrose, it would prove of the greatest value to the country.

It is easy to see the advantage of an experiment carried on in this systematic way and under the same conditions of cultivation and analysis.

Soil and climate, it will be seen, are the only variables, and hence their influence could be easily traced. I do not wish to say that one year's experience in the manner described would be sufficient to determine all the doubtful questions in the sorghum problem. But the advantage of this method will be so apparent that there will be no difficulty in securing its continuance for a number of years. It will be an experiment carried on all over the country, in which every State will feel an interest and every community secure a benefit.

In a matter of such national importance, experiments made at Washington, at Rio Grande, and at Sterling are not enough. It is necessary to place the whole country under investigation that the whole country may be benefited.

When once the parts of the country where climate and soil are most favorable to the growth of sorghum have been determined, the second great factor of the problem must be considered. This relates to the constitution of the plant itself.

I have asked the botanist of the Department, Dr. George Vasey, to give me a brief botanical history of the sorghum plant, which I will insert here:

SORGHUM VULGARE, Persoon.

This species is now considered by the best botanists to include all the very numerous varieties which are cultivated as sorghum, sugar cane, broom corn, Dourra corn or Guinea corn. They have been cultivated for unknown ages in China, India, and Africa. About 1851 or 1852 it was introduced from China to France, and the seed soon afterwards sold by Messrs. Vilmorin & Co., of Paris. About the same time Mr. Leonard Wray, a practical sugar planter, on a visit to Kaffirland, found the Imphee cultivated by the natives, the stalks of which they chewed for the sake of the rich, sweet juice. Mr. Wray brought seed of the plant to England, where he had it planted, and also in France and Belgium.

In 1853 Dr. J. Browne obtained some seeds of Messrs. Vilmorin & Co. for the Department of Agriculture, and in 1854 a portion of these seeds were distributed by the Department for trial. In 1856 Mr. Orange Judd obtained and distributed to subscribers of the American Agriculturist 25,000 packages of sorghum seed. Thus the plant became introduced into various parts of the United States.

The botanical characters may be briefly given as follows: Flowers in an ample terminal panicle, loose and spreading, or close and rather compact, erect or nodding. The flowers are on the small branches near the extremity. If they are examine while young it will be observed that there are two kinds of flowers, one perfect and finally producing seed, the other containing only male organs or empty. The male or sterile flowers are on short stalks, one or two at the base of each perfect flower, which is sessile or without a stalk. At or near maturity the sterile flowers drop off, leaving still remaining the short stem or stems on which they were borne. The perfect spikelet has two outer glumes, tough and leathery, and two smaller, thin, delicate, transparent inner ones, one of which is two-lobed at the apex, and between the lobes extended into a short, rigid, bent, and twisted awn. The stamens are three, the stigmas plumose. The sterile spikelets are narrower, the outer glumes without the leathery texture, nerved longitudinally, the two inner ones thin and delicate, destitute of the awn, and containing three stamens.

STRUCTURE OF THE LEAF, STALK, AND SEED OF THE SORGHUM PLANT.

The following figures show the cell structure of the stalks, leaf, and seed:

FIG. 1.—Horizontal section of the stalk, magnified 18 diameters.
FIG. 2.—Cross-section of leaf, magnified 18 diameters.
FIG. 3.—Section of seed, magnified 18 diameters.

CELLULOSE.

The cell walls are composed of cellulose and the tough fibers of the outside coatings are of the same material. From a large number of determinations I have found that the amount of cellulose and insoluble matter in the stalks of the sorghum is not far from 11 per cent. This amount varies greatly with the character of the cane, and the extremes of variation may deviate as much as two per cent. from this mean.

Percentage of cellulose and substances insoluble in water in sorghum canes.

	Weight taken.	Weight of residue.	Per cent. of cellulose.
	Grams.	*Grams.*	
No. 1..	50.00	5.450	10.90
No. 2..	50.00	5.370	10.74
No. 3..	50.00	5.355	10.71
No. 4..	50.00	5.420	10.84

WATER.

In the cells the sugars of the cane are stored, always, I believe, in a state of solution. I know it has been claimed that the sugar in the cells is often crystallized. I have never been able to see these crystals, and I have never seen any one who has seen them.

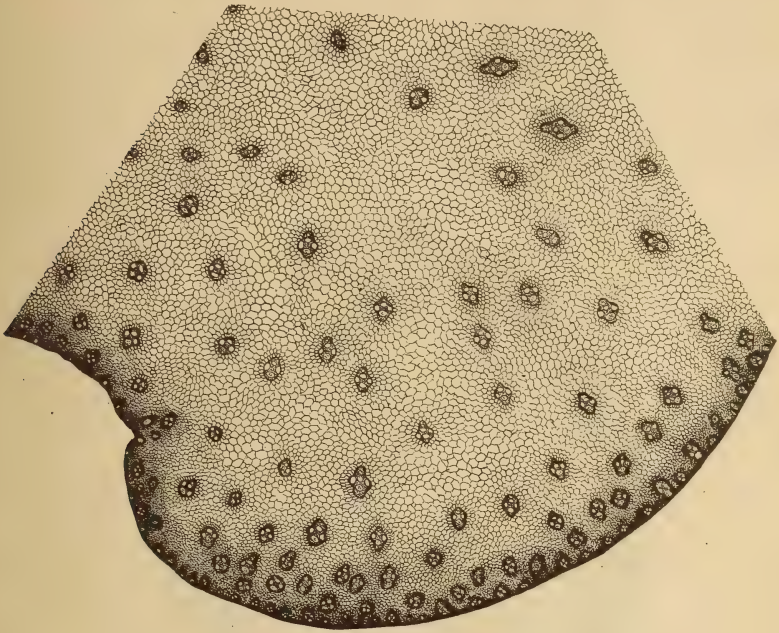

FIG. 1.

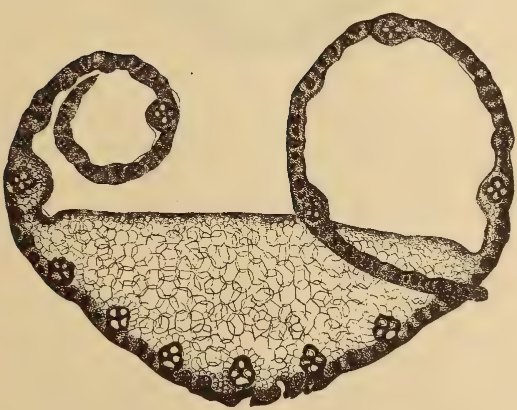

FIG. 2.

Lately the agricultural experiment station of New Jersey, Bulletin No. XXX, in explaining the loss of sugar in the bagasse, has said:

> To explain this it is necessary to assume that a considerable portion of the sugar is stored in the cane in a solid state, either as pure crystallized sugar or in some combination easily decomposed or dissolved in water.

Inasmuch as crystals of sugar, or sugar in a solid state in the stalks, have not been actually seen at the New Jersey station, I am inclined to think that it will be necessary to seek some other cause for the anomaly mentioned.

Cane sugar is remarkably soluble in water, and the proportion of sugar to water in the stalks would have to be nearly three to one before we could look for a crystallization.

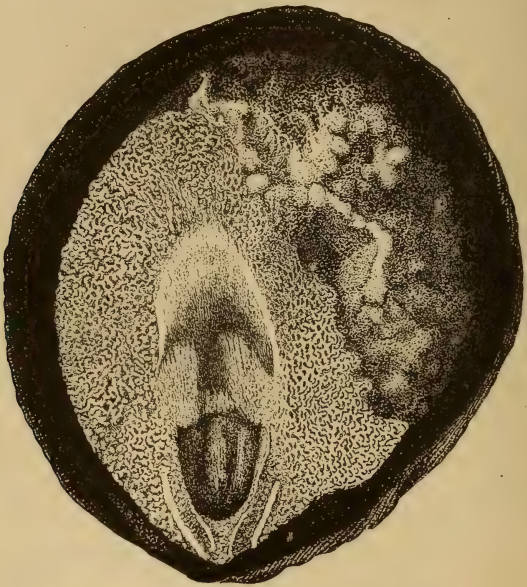

FIG. 3.

The quantity of water and substances soluble therein at 100° C. in the sorghum cane I have determined by a large number of analyses. The average per cent. is about 8.9.*

It is proper to state here that the analyses of the canes on which this and the following results are based were made on the variety known as Link's Hybrid. These canes pressed in the experimental mill yielded 64 per cent. of juice, which gave an average analysis of about 9.0 per cent. sucrose and 3.0 per cent. other sugars. This is a better average analysis than that of 300 tons of amber cane worked earlier in the season for sugar.

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* For formula to calculate the percentage of water in cane, see Bulletin No. 2, Chem. Division, p. 5.

I wish it distinctly understood that I do not set up these results as a standard by which other varieties of cane grown under other conditions are to be judged. I think, however, that they will fairly represent the sorghum cane grown and manufactured in the United States during the past season.

Naturally when we find a cane richer in sugar than the average just given, we would expect to find a diminution in the quantity of water. Thus when the percentage of sugar to weight of cane rises to 16.09, as in one instance in the New Jersey report already referred to, it is hard to see how the percentage of water could be much over 70.

But in more than a thousand analyses, extending over two seasons and embracing canes of several varieties and grown in various parts of the country, I have never yet found a sample in which the sucrose was greatly more than 10 per cent. of the total weight of the cane. In general, therefore, we may conclude that canes when ripe have a content of water varying from 72 per cent. for the best varieties to 80 per cent. for the poorest.

OTHER SUGARS.

The sorghum cane contains sugars which are not sucrose. This is a point of great inferiority in sorghum, as compared with the sugar beet, regarded as a sucrose-producing plant. These sugars (I speak of them in the plural, because there ar at least two of them) are not crystallizable in the ordinary way. The term *glucose* has been generally applied to them. This term, however, is a general one, and may be applied to any sweet substance.

The chief one of these "other sugars" present in the cane is one which does not in any way affect the plane of polarized light. It is, therefore, a sugar unique, and I propose to call it *anoptose*, a term which signifies a sugar without influence on the polarized ray.

It is probable that in normal ripe sorghum cane sucrose and anoptose are the only sugars present. If, however, the cane is abnormal, *i. e.*, injured or frost-bitten, or kept exposed a long time after cutting, the sucrose undergoes a transformation. It is converted into *invert sugar*, which, at temperatures below 90° C., has a left-handed rotatory power.

For practical purposes these sugars may be regarded as the same, although it is necessary to carefully distinguish them in optical analysis.

In nearly 300 tons of Early Amber cane (mean of over 300 analyses) the amount of anoptose and invertose was 4.09 per cent. in the expressed juice. The mean of numerous analyses of the best samples of Link's Hybrid canes showed about 3 per cent. of these sugars to the total weight of cane. I think that if we take the sorghum crop as it is grown now throughout the country 3.00 per cent. of uncrystallizable sugar will not be a high figure. My experiments and observations show that in general, we cannot count on a better ratio than one of anoptose to three of sucrose as an average for the whole country.

SOLUBLE SOLIDS NOT SUGAR.

Under this head we must consider the soluble starch and gums, the acids, the chlorophyl, the mineral substances, and all else not sugar, soluble in water or expressed by the mill with the juice. In every case where I have tested a sorghum juice for starch, I have found that body present. I have made no attempts to determine its quantity.

Some varieties of canes have gums besides the starch. These gums resemble the hydrocarbons, and are doubtless isomers of starch or sugar. They have a strong rotatory power to the right, like starch, and the dextrine derived from it by long boiling.

The starch and dextrine have to be taken into consideration in optical analysis. Thus a raw sugar which polarized 93° on direct reading, only calculated 89 per cent. after inversion. Thus an amount of dextrogyratory matter *not sucrose* was present to increase the readings four degrees to the right. In meladas, sirups, and molasses, on the other hand, the first polarization generally gives too low a result, owing to presence of invert sugar.

The free acids vary in amount from .1 to .2 per cent. There is also acid present combined with the potash and other bases found in the ash. It is probable that a large number of acids will be found in the cane. Among those which have already been detected I may mention malic and aconitic.

The formula of malic acid is $H_2 C_4 H_4 O_5$, and its calcium salt $Ca C_4 H_4 O_5$.

The formula of aconitic acid is $H_3 C_6 H_3 O_6$, and its calcium salt $Ca_3 (C_6 H_3 O_6)_2$.

It requires nearly 2.5 parts of slaked lime to saturate 1 part of malic acid, and a little over 2 parts for 1 part of aconitic acid. In estimating the acid of cane juice it is usually determined as malic acid. One liter of cane juice having an acidity of .15 per cent. would contain 1.5 grams free acid, requiring 4 grams calcium hydrate for its saturation. The lime compounds of these organic acids are quite insoluble, and can therefore be separated by subsidence or filtration.

ASH.

The mineral constituents of the cane are recovered in the ash, but not in the form of combination in which they exist in the canes. The average amount of ash in the canes is not far from 0.62 per cent.

Ash in sorghum cane chips.

	Per cent.
No. 1	.6172
No. 2	.6380
No. 3	.5956
No. 4	.6424
No. 5	.6568
No. 6	.6300
No. 7	.5772
No. 8	.6508
No. 9	.5924
No. 10	.6128
Average	.62132

Compare this with the ash in the sugar beet.

Ash in sugar beets.

Beets from Oswego, N. Y.:	Per cent. ash.
No. 1	1.022
No. 2	1.079
No. 3	1.049
No. 4	.775
No. 5	.862
No. 6	1.051
No. 7	.983
No. 8	.985
No. 9	1.099
No. 10	1.166
No. 11	.897
No. 12	1.250
From York, Pa.:	
No. 13	1.317
No. 14	1.574
Average	1.30

Horsin-Deon* gives the mean percentage of ash in the beet as 1.131.

Composition of the ash of the sugar beet.†

Potash	45.87
Lime	8.26
Magnesia	5.50
Soda	10.09
Phosphoric acid	11.47
Sulphuric acid	2.75
Chlorine	4.59
Silica	11.47
	100.00

From these analyses, it is seen that the sugar beet contains nearly twice as much ash as the stalks of sorghum.

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* Traité Théorique et Pratique de la Fabrication du sucre, Paris, 1882, page 3.

† Horsin-Deon, *op. cit.*, p. 32.

From analyses given in the Agricultural Report for 1880, page 126 I take the following mean composition of the ash:

Constituents.	1.	2.	Mean.
Potassium as oxide	49.66	33.77	41.71
Polassium as metal*	4.31	14.58	9.44
Lime	13.49	9.00	11.24
Magnesia	10.47	10.28	10.37
Silica	8.97	2.93	5.95
Sulphuric anchydride (acid)	5.55	11.70	4.07
Chlorine	3.91	13.24	8.57

* Combined with chlorine, &c.

The following analysis represents the composition of the ash of numerous samples of Link's hybrid cane, cut into fine chips and carefully sampled. After incineration and intimate mixture of all the samples, the examination of the ash gave the following data:

Analysis of sorghum cane ash.

	Per cent.
Silica	19.45
Potash K_2O	34.58
Soda Na_2O	3.02
Phosphoric acid P_2O_5	4.53
Sulphuric acid SO_3	4.20
Lime, CaO	10.16
Magnesia, MgO	13.07
Chlorine	.21
Oxide of iron and alumina, &c	Trace.
Undetermined, &c	10.78
	100.00

I give also analysis of the ash of Amber cane grown in Italy:

*Ash of Amber cane.**

CLEAN CANE.

	Per cent.
Potash	33.1019
Soda	2.0341
Lime	14.0000
Magnesia	7.2903
Phosphoric acid	6.8108
Sulphuric acid	4.1886
Hydrochloric acid	3.1705
Carbonic anhydride	6.0347
Soluble silica	0.8241
Insoluble silica	7.0329
Trace of carbon	15.5121
Oxide of iron	
Oxide of aluminum	
Matters not determined	
	100.0000

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* L' Ambra Primaticcia o Sorgo Zuccherino del Minnesota. Prof. Giulio Monselise. Mantova, 1883. P. 110.

The analysis of the ash, taken with that of the soil, is a good guide for the application of mineral fertilizers. Sorghum, it is seen, is a much less rapacious potash and phosphoric acid consumer than the sugar beet.

PERCENTAGE OF BLADES.

This is a question which often is presented to the manufacturer. Sometimes he buys clean canes, and again those which still retain the blades. Many experiments have been made to determine this ratio, but the results vary so widely and depend on so many different conditions that a generalization is almost impossible.

When the leaves are all green and covered with dew the percentage is naturally greater than when they have been killed by frost and are dry. With perfectly green leaves their weight will probably be 10 per cent. that of the topped canes. When they are dry and frost-bitten it may not be more than 4 per cent. An allowance of 10 per cent. the season through, dry and wet, green and dead, will not be far out of the way.

In the New Jersey Bulletin No. XXX (already quoted) sixteen trials gave the highest percentage of blades 9.1 and the lowest 4.6. In four trials with the Early Amber cane, grown by the Department, I found the percentages of blades 10.5, 11.7, 10.6, and 10.4, respectively.

IMMEDIATE WORKING.

In a general discussion of the characteristics of the sorghum cane, its tendency to rapid change must not be neglected. It is a false economy, a misguided enthusiasm, and a pseudo science that would try to conceal from the people the weak points of a great national industry. This proneness to change is a radical fault of the sorghum as compared with the sugar beet, and even with the tropical cane; and one, I fear, which no amount of improvement by culture will ever be able to wholly eradicate. I made some experiments during the early part of the fall to transport canes from different parts of the country to Washington for analysis. The canes were carefully cut. The blades and tops were not removed. The cut surfaces were thoroughly covered with melted wax. The canes were then wrapped in stiff paper with a stick longer than the longest cane, to prevent breaking, and sent by express. All those packages which reached me within four days were found to be apparently unchanged. One sample which did not receive attention until the fifth day was found to be considerably changed. The weather was warm when these shipments took place, which made the tendency to change greater.

Canes prepared as above and kept in a cool place could doubtless be kept many days without injurious effects, but there is always more or less danger of the sugar becoming inverted. The conditions most favorable to this inversion are rapid changes of temperature with high maxima. Canes cut and left in the field, exposed to hot September suns and cool September nights, will soon have all their sucrose destroyed. This inversion is doubtless due to a kind of fermentation, without any marked vinous or other common character. Canes thus changed are still fit for sirup-making, but are worse than useless for the production of sugar.

In silos, as I have already shown, where the changes of temperature are moderate and slow, the canes may be kept for a long time without undergoing any serious deterioration.

It could be reasonably inferred from these facts that sudden temperature changes injure the delicate cell structure of the cane and thus by the rupture of the cells favor the process of inversion. No histological investigations have been made, however, to confirm this supposition. It may be that the presence of anoptose and a trace of invert sugar mixed with the sucrose in the cells greatly facilitates this change—a danger which the sugar in the beet cells is not subject to. The sorghum is much more subject to this inversion change than the tropical cane, as I have said. It is not uncommon in the South to have three or four days run of cane on hand at the mill; a method of procedure that would be attended with disastrous results with sorghum.

In a sample of Louisiana cane sent to the President and thence to my division for analysis, I found nearly 16 per cent. of sucrose and little more than 1 per cent. of other sugars. The canes had been cut at least two weeks.

ANALYSIS OF LOUISIANA CANES DECEMBER 11.

	Per cent.
Sucrose	15.68
Other sugars	1.13

AVAILABLE SUGAR.

By this expression I mean the proportion of sugar which can be obtained in a dry crystallized form from the canes. Its amount depends on the percentage of juice extracted from the cane, and the ratio of sucrose to the other bodies in the juice.

I will not stop here to consider the question of the expression of the juice, a subject which has been discussed in a special report.* I will assume for the present, and the assumption will not be far from the truth, that the amount of juice expressed will average about one-half the weight of the cane. Long experience has shown that each equivalent of substance not sugar in the juice prevents a like quantity of sucrose from being obtained in a crystalline state. To this we must add another result of experience, viz: that about 5 per cent. of the sucrose is lost in the process of evaporation.

Apply these data to a cane yielding a juice containing 10 per cent. sucose, 2.75 per cent. other sugars and 2 per cent. solids not sugar. Adding together the anoptose and non-saccharine solids, we get 4.75 per cent. This will prevent an equal quantity of sucrose from crystallizing, and there will be left of sucrose 10−4.75=5.25 per cent. Deduct the 5 per cent. lost in evaporation and there is left 4.75 per cent. of sugar which can be obtained in marketable form. This is calculated on the weight of the juice, and for the weight of cane must be divided by two. The percentage of sugar obtainable, therefore, based on total weight of cane worked, is only 2.37 or 46.4 pounds per ton.

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*Diffusion applied to Sorghum Cane. Chemical Division, United States Department Agriculture. Bulletin No. 2.

I doubt whether any factory in the country this year working sorghum cane exceeded that yield on the whole amount of cane worked up.

In the cane worked at the Department of Agriculture during the past season the average analysis of the juices was—

Sucrose	per cent.	*8.84
Other sugars	do	4.00
Solids, not sugar (a little less than)	do	2.00
Five per cent. loss	do	.42
Available sugar	do	2.42
Yield of juice	do	42.00
Available sugar per ton	pounds	20.30

This was almost the exact quantity obtained save from 5 acres of cane raised in Indiana, which gave over 60 pounds per ton. At Rio Grande the percentage of juice extracted was 47†; the sucrose was 9.75; other sugars and total solids not given.

At Champaign,‡ Ill., the percentage of juice expressed was 60; percentage of sucrose, 7.78; percentage of other sugars, 4.70; specific gravity, 1.0591.

COEFFICIENT OF PURITY.

There is another method of expressing the ratio of sucrose to other substances present in saccharine juices which is more convenient but less accurate than the number expressing available sugar. It is generally used in the beet-sugar countries, and for rich juices is near enough the percentage of available sugar for practical purposes.

The "coefficient of purity" is the ratio per cent. of the total sucrose in a juice to the total solids. Thus in a juice containing 14 per cent. total solids and 10 per cent. sucrose, the figure for purity coefficient is 71.5. Really, in this case only 60 per cent. of the sucrose present is available. and hence the purity coefficient number is too high for available sugar.

In a case, however, where the sucrose is only half the total solids (which often happens with sorghum juice) the purity coefficient would be 50, while the available sugar would be 0!

During the past season the juices worked for sugar at Washington

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* In the juices worked for sugar.

† Double milling. This number is the average of the numbers given by the superintendent. (See letter of Mr. Hughes, p. 60.)

‡ See letter from superintendent, p. 62.

had an average purity coefficient of about 60. I doubt whether it will ever prove profitable to work juices of such a low order for sugar. They will make good sirup, but necessarily will yield only a small percentage of sugar. In a practical way farmers and manufacturers can determine the value of their cane juices as follows: The juice, as it comes from the mill or diffuser, is allowed to stand for half an hour and cooled to a temperature near 15° C. (60° F.). Its specific gravity is then taken by a hydrometer. I would advise always the use of a hydrometer graduated with numbers giving the specific gravity directly. If a Baumé spindle is used, the specific gravity can be calculated by the following formula:

Let s=sp. gr., and g=reading on scale of hydrometer.

Then $s=\frac{144}{144-g}$

EXAMPLE: Let the hydrometer reading be 8°.

$$\text{Then } s=\frac{144}{144-8}=\text{sp. gr.}=1.0588$$

For Beck's hydrometer the formula is—

$$s=\frac{170}{170-g}$$

For Brix's:

$$s=\frac{400}{400-g}$$

For Twaddle's:

$$s=\frac{\frac{g}{2}+100}{100}$$

For Balling's:

$$s=\frac{200}{200-g}$$

Having determined the specific gravity the percentage of total sugars can be roughly estimated by the appended table. Since the proportion of solids, not sugar, to the sugars in sorghum juices may be estimated at 1.3:12,[*] and since these solids in solution may be considered for practical purposes to have the same specific gravity as the sugars, it is easy to calculate from the specific gravity the proportion of sugars present.

For example, a juice shows a specific gravity of 1.059, corresponding to a percentage of pure sugar of 14.42. Make the proportion—

$$12:1.3::14.42:x$$
$$\therefore x=1.56$$

and 14.42—1.56=12.86=percentage of total sugars present in juice.

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[*] Fifty-one analyses of fresh juices from more than 300 tons of ripe Amber cane gave total solids, 14.06; total sugars, 12.68; solids not sugar, 1.38.

In the table I will give this approximate calculation for sorghum juices and sirups.

If the coefficient of purity is desired it will be necessary to determine the percentage of sucrose in the juice, either by the polariscope or a chemical analysis.

Table showing approximate total solids and total sugars in sorghum juices and sirups.

Specific gravity.	Per cent. solids, calculated as pure sugar.	Approximate per cent. of total sugars.
1.0000	.00	.00
1.0035	.90	.80
1.0070	1.80	1.60
1.0105	2.69	2.39
1.0141	3.59	3.20
1.0177	4.49	4.00
1.0213	5.39	4.80
1.0249	6.29	5.50
1.0286	7.19	6.41
1.0323	8.09	7.21
1.0360	9.00	8.02
1.0397	9.90	8.82
1.0435	10.80	8.93
1.0473	11.70	10.43
1.0511	12.61	11.24
1.0549	13.51	12.04
1.0588	14.42	12.85
1.0627	15.32	13.66
1.0667	16.23	14.43
1.0706	17.14	15.28
1.0746	18.05	16.09
1.0787	18.96	16.90
1.0827	19.87	17.61
1.0868	20.78	18.52
1.0909	21.69	19.24
1.0951	22.60	20.15
1.0992	23.52	20.97
1.1034	24.43	21.78
1.1077	25.35	22.60
1.1120	26.27	23.42
1.1163	27.19	24.24
1.1206	28.10	25.05
1.1250	29.03	25.88
1.1294	29.95	26.05
1.1339	30.87	27.52
1.1383	31.79	28.34
1.1429	32.72	29.17
1.1474	33.65	30.00
1.1520	34.58	30.83
1.1566	35.50	31.65
1.1613	36.44	32.14
1.1660	37.37	33.32
1.1707	38.30	34.15
1.1755	39.24	34.99
1.1803	40.17	35.91
1.1852	41.11	36.65
1.1901	42.05	37.49
1.1950	42.99	38.24
1.2000	43.94	39.17
1.2050	44.88	40.01
1.2101	45.83	40.86
1.2152	46.78	41.71
1.2203	47.73	42.55
1.2255	48.68	43.30
1.2308	49.63	44.25
1.2361	50.59	45.10
1.2414	51.55	45.96
1.2468	52.51	46.82
1.2522	53.47	47.67
1.2576	54.44	48.54
1.2632	55.47	49.46
1.2687	56.37	50.26
1.2743	57.34	51.12
1.2800	58.32	52.00
1.2857	59.29	52.86
1.2915	60.27	53.74
1.2973	61.25	54.81
1.3032	62.23	55.48
1.3091	63.22	56.27
1.3151	64.21	57.25

Table showing approximate total solids and total sugars, &c.—Continued.

Specific gravity.	Per cent. solids, calculated as pure sugar.	Approximate per cent. of total sugars.
1. 3211	65. 20	58. 13
1. 3272	66. 19	59. 01
1. 3333	67. 19	59. 91
1. 3395	68. 19	60. 70
1. 3458	69. 19	61. 69
1. 3521	70. 20	62. 59
1. 3585	71. 20	63. 48
1. 3649	72. 22	64. 39
1. 3714	73. 23	65. 29
1. 3780	74. 25	66 20
1. 3846	75. 27	67. 11
1. 3913	76. 29	67. 92
1. 3981	77. 32	68. 94
1. 4049	78. 35	69. 86
1. 4118	79. 39	70. 78
1. 4187	80. 43	71. 71
1. 4267	81. 47	72. 65
1. 4328	82. 51	73. 52
1. 4400	83. 56	74. 50
1. 4472	84. 62	75. 45
1. 4545	85. 68	76. 39
1. 4619	86. 74	77. 34
1. 4694	87. 81	78. 29
1. 4769	88. 81	79. 18
1. 4845	89. 96	80. 21
1. 4922	91. 03	81. 17
1. 5000	92. 12	82. 14
1. 5079	93. 21	83. 11
1. 5158	94. 30	84. 08
1. 5238	95. 40	85. 06
1. 5319	96. 51	86. 05
1. 5401	97. 62	87. 04
1. 5484	98. 73	88. 03
1. 5568	99. 85	89. 03

QUANTITY OF SORGHUM SUGAR MADE AT PRINCIPAL FACTORIES IN THE UNITED STATES DURING 1883.

From the data at the office of the division of statistics the production of sorghum sugar during the past season was as follows:

	Pounds.
Rio Grande, N. J	282, 711
Champaign, Ill	160, 000
Sterling, Kans	136, 000
Hutchinson, Kans	131, 000
Ottawa, Kans	7, 000
Department of Agriculture	10, 000
Total	726, 711

THE BEET-SUGAR INDUSTRY.

The beet sugar made in the United States during the campaign of 1883–84 was all manufactured at Alvarado, Cal. The following letter of Mr. E. H. Dyer, superintendent of the Standard Sugar Refinery, Alvarado, Cal., will show the character of the work which is doing in California with the sugar beet:

H. W. WILEY, Esq.,
Chemist, Department of Agriculture, Washington, D. C.:

DEAR SIR: Yours of 5th instant received. In answer to your inquiry in regard to the amount of sugar made in campaign 1883–84, will state that our whole product has not yet been marketed. We only had beets enough to run about ninety days, owing to the unusually dry season that prevented the farmers from sowing only about one-half the usual acreage. We sent to market, however, 1,027,826 pounds *white refined sugar*, and probably have in tanks, in process of crystallization, 250,000 pounds more. The percentage of sugar obtained was very satisfactory. As this season promises to be a favorable one, we expect to have from 15,000 to 20,000 tons of beets. Last year we only had about 7,000 tons.

The five years' experience of the Standard Sugar Refinery has fully proven that beets raised in California will yield as many tons per acre and are as rich in saccharine matter as any produced in Europe. With the aid to this industry that its importance deserves for a few years, sufficient capital would be invested in the production of beet sugar to stop all importation of foreign sugar on the Pacific coast, and supply a large portion of that required east of the Rocky Mountains. We have a soil and climate well adapted to the production of the sugar beet, extending from California to British Columbia. There is room for one hundred factories of a daily capacity of 150 tons each; and with the same encouragement by our Government as the manufacturers in Europe received in the earlier stages of the industry, they would be built in less than 10 years. I will gladly give you any information in regard to the subject that I have, fully realizing that the future success of this important industry depends greatly, if not wholly, upon the encouragement given it by your Department. I intend visiting Washington during the session of Congress for the purpose of trying to obtain a modification of the internal-revenue laws that will permit alcohol distilled from beet molasses, to be used solely for mechanical purposes, to be exempt from taxation.

Yours, respectfully,

E. H. DYER.

From this letter of Mr. Dyer, it is evident that the manufacture of sugar from the sugar beet is an assured success on the Pacific coast. There is a vast region of country in Northern California, Oregon, and Washington Territory of which the climate and soil are suitable to this plant.* When the extent of this region is considered it does not seem that Mr. Dyer's views of the future are exaggerated. I do not have any data of complete analyses of California beets. The following data are taken from "The Sugar Beet":†

(1) Imported Vilmorin beet:
Density of juice, 26° Balling.
Coefficient of purity, 82°.6.

(2) Early Red Top beet:
Density of juice, 23°.2 Balling.
Coefficient of purity, 82°.5.

(3) Verbesserte Imperial Rose:
Density of juice, 20°.5 Balling.
Coefficient of purity, 83°.

The preceding analyses were made by Mr. P. Cassamajor.

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*McMurtrie, Culture of Sugar Beet. U. S. Agricultural Special Report No. 28. See map opposite page 28.

†The Sugar Beet, Vol. 5, No. 1.

The following analyses were made in California:

No.	Variety.	Degree, Brix.	Sucrose by polarization.	Coefficient of purity.
1	Early Rose	19.5	16.	82.05
2	Vilmorin Imperial	20.5	16.7	81.46
3	Verbesserte Imperial Rose	19	15.2	80
4	do	17	14.4	80

The yield per ton of the California beets is most gratifying.

Seven thousand tons of beets were worked. The yield per ton on the basis of the sugar already marketed is 147 pounds. Allowing for the estimate of Mr. Dyer that 250,000 pounds of sugar are yet to be separated, the total yield reaches 182 pounds per ton.

These figures should prove of the greatest interest to the farmers of the Pacific slope, for in them they should see suggestions of greater wealth than is found in their mines.

SUGAR BEETS FROM OTHER LOCALITIES.

I have had few opportunities of examining sugar beets, and give below the analyses of all that have been sent to the Department.

The beets analyzed in the following table were raised by Mr. William Cartwright, of Oswego, N. Y. He planted a space of 46,708 square feet in beets, and the total yield was 36,000 pounds.

Analyses of beets from Oswego, N. Y.

Variety.	No. of analysis.	No. beets taken.	Weights.	Weight with neck removed.	Sucrose.	Glucose.	Ash.	Purity.
			Kilograms.	*Kilograms.*	*Per cent.*	*Per cent.*	*Per cent.*	*Coef.*
Improved, south field, north end	1	5	2.838	Not taken	12.12	.29	1.022	74.6
Massachusetts, improved	2	5	2.963	....do.....	12.58	.20	1.079	77
Late-planted, pitted in field	3	5	1.961	... do.....	11.22	.22	1.049	71.9
Improved, south field, south end	4	5	2.457	2.238	15.34	.17	0.775	83
Improved, north field, north end	5	5	2.776	2.610	15.32	.16	0.862	85
Improved, north field, south end	6	5	2.795	2.540	15.20	.12	1.061	82
Oswego seed	7	5	2.902	2.532	14.52	.14	0.983	80
Government seed:								
Sub. Green Neck	8	5	2.477	2.010	12.54	.14	0.985	74
Rose Neck	9	4	2.807	2.598	12.24	.31	1.099	77
Sublime, 1883	10	4	4.272	3.822	11.06	.32	1.166	72
From Hart's field	11	5	2.915	2.810	12.74	.40	0.897	79
Late-planted	12	6	2.020	2.020	12.64	.32	1.250	78.5

SUGAR BEETS SENT BY MR. LEVI MAISH, YORK, PA.

Beets sent, November 22, 1883.
Analyzed, December 19, 1883.

ANALYSES.

No.	Variety.	No. of beets.	Total weight.	Weight without neck.	Sucrose.	Glucose.	Ash.	Purity.
			Kilos.	*Kilos.*	*Per cent.*	*Per cent.*	*Per cent.*	*Coef.*
1	Vilmorin Improved	4	2.924	2.684	8.04	.40	1.37	64.3
2	White Silesian	3	2.892	2.610	7.24	.78	1.57	58

By comparing the analyses of these beets with those from Oswego, the great superiority of the latter is at once manifest.

York, Pa., seems to be too far south for successful culture of the sugar beet.

In the attempts which have been made in the United States to establish the sugar-beet industry, the cause of failure has generally been inability to obtain sufficient beets. There is little doubt but that quite a wide territory can be found in our most northern States in which both soil and climate are favorable to a development of the beet sugar industry. The experience of Europe for nearly a century is at our disposal. The Department of Agriculture would do a great work for the Northern farmers by determining experimentally the best localities for the culture of the sugar beet.

FURTHER STUDY OF THE SORGHUM INDUSTRY.

It is readily seen from these figures that the importance of sorghum sugar from a commercial view is altogether in its possibilities and not in its actual magnitude. The predictions made a few years ago by many honest enthusiasts, that in five years (the time has already expired) our country would make its own sugar, are yet far from being fulfilled.

The fact must be admitted that the present production of sorghum sugar is not a very encouraging one for thirty years of endeavor. But there is one encouraging aspect of this statement, viz, that nearly all the progress in sugar-making has taken place during the past three years. A careful study of the results obtained, and which can be relied upon as exact, during the last few years, will lead to some interesting deductions. These of course may be modified by subsequent experience, but they appear to be justified by the present condition of the industry.

GENERAL CONCLUSIONS.

SMALL MILLS.

The prevalent idea that each farmer will become his own sugar-maker I do not hesitate to pronounce erroneous. For nearly thirty years such experiments have been carried on by farmers throughout the middle and northern parts of the country and yet no permanent success has attended them.

In many cases even the sirups made in this small way are far from being palatable. They often contain the acids and other impurities of the juice, and have an acrid, unpleasant taste.

The successful manufacture of sorghum sugar presents greater difficulties than the working of the sugar beet. In this there is only one sugar, viz, sucrose, and its separation is not hindered and even prevented by large quantities of its uncrystallizable kindred. Three-quarters of a century have placed the manufacture of beet sugar on a paying basis, but have not brought it to its limits of perfection.

The sorghum sugar industry in this country is yet in its infancy, and it is not strange that its methods are still crude and unsatisfactory. It seems that the advocates of the industry have often had more zeal than knowledge, and I have noticed that with increasing experience the prophecies of experts have grown less extravagant. If the success of small mills has been almost none, it does not follow that that of large ones has been great. But one thing the large factories have shown, *i. e.*, that sugar can be made; how profitably or unprofitably cannot yet be said.

The factories at Rio Grande, N. J., Champaign, Ill., Sterling and Hutchinson, Kans., have made sugar this year, in all nearly 1,000,000 pounds. But 1,000,000 pounds is a small contribution to the sugar consumption of the country, and the time appears still distant when the United States will make its own sugar.

Near large factories farmers may make their own sugar by raising a few acres of cane and exchanging it at the factory for sugar. Cane that will produce 60 pounds sugar to the ton ought to yield the farme 35 pounds of sugar. The other 25 pounds and the molasses would pay for working, and yield, I think, a fair profit. Under these most favorable conditions the farmer would get 350 pounds sugar per acre. I do not know of any other way in which he can get that much sugar out of an acre of sorghum cane. I do not write in this manner to discourage efforts to make sugar profitably in a small way, either at present or in the future. The small sorghum factories, with their crude sheds and mills and often cruder methods of concentration, will continue to dot the landscape of the central and northern belt of States, and the products of these establishments, when made by intelligent direction, will continue for many years to be sources of profit to the industrious farmer and manufacturer.

If a method for making sugar profitably on a small scale could be devised, it would certainly be a great advantage to our farmers. The cost of the sugar for a farmer's family is one of the chief expenses of the household, and often takes so much of his available cash that he finds it difficult to raise money to pay his taxes. If large factories are started throughout the country, the farmer may find it profitable to cultivate cane and sell it to the manufacturer. What price should be paid for canes, and how their value should be determined, are questions which the ordinary experience of commerce will answer.

LARGE FACTORIES.

Only the large establishment can with economy employ the chemist and the skilled laborer. It requires as much chemical science and as much skilled labor, to work one ton of cane into sugar as it does a thousand. Moreover, sugar machinery is expensive. The boilers and engines must be large and of the best quality. The mills and diffusers are heavy and costly. Then come the open evaporators, the double and triple effect and strike vacuum pans, with their pumps and appurtenances. Then the sugar wagons and centrifugals are not to be forgotten. If animal char is employed, it requires additional and expensive apparatus. Counting every expense except the cost of land, the capital required to work 10,000 tons of cane per season will not fall much short of $75,000. It may exceed that sum if strong, permanent buildings are erected.

REVIEW OF THE SORGHUM INDUSTRY DURING 1883.

EXPERIMENTS MADE BY DEPARTMENT OF AGRICULTURE.

(1) *Field of cane near Washington.*

Following is the report of Mr. Nesbit, who had charge of the field:

DEPARTMENT OF AGRICULTURE,
Washington, *December* 3, 1883.

DEAR SIR: Your letter of November 23 to Hon. George B. Loring, Commissioner, requesting "for insertion in the forthcoming report on sorghum a report on the following items:

(1) Plowing and preparing ground;
(2) Fertilizer employed, when and how applied;
(3) Date and method of planting;
(4) Cultivation;
(5) Other items of interest in connection with the crop;"

Having been referred to me, I take pleasure in furnishing the desired information.

(1) A contract for the plowing was given on the 27th day of March, requiring that "the ground shall be plowed to a uniform depth of 5 inches, and a subsoil plow shall be run in each furrow to the uniform depth of 6 inches below the bottom of the furrow." Other stipulations were made requiring the work to be well done, and finished before the first day of May. The weather proved exceedingly unfavorable, so that much of the time the ground was too wet to be worked, and the plowing was not completed until May 18. A drag-harrow, disk-harrow, and clod-crusher were employed to reduce the ground to good tilth.

(2 and 3) The seed was planted and fertilizer applied with a grain-drill having a fertilizer attachment. Two of the eight tubes, 3½ feet apart, were used for seed, and the same, together with one more on each side of both seed-tubes, six in all, were used for the fertilizer. The other tubes were entirely shut off. The planting was begun on the 14th of May and finished on the last of May, much rain intervening and preventing a more rapid prosecution of the work. The fertilizer was applied at the rate of 500 pounds per acre. An analysis by Mr. Clifford Richardson, assistant chemist, showed the following constituents, viz:

Soluble phosphoric acid	per cent	6.55
Reverted	do	3.85
Available	do	10.40
Total	do	11.82
Nitrogen	do	1.79
Equivalent to ammonia	do	2.17
Commercial value		$30.50

(4) The first cultivation after planting was broadcast with a smoothing harrow. After this the sorghum was thinned to a stand of about 12 stalks to a yard by cross-

ing the rows with a spring-tooth cultivator, having a part of the teeth removed, followed by hand and hoe work. In the after cultivation a sulky cultivator and one or two one-horse cultivators were constantly employed, when the condition of the ground would permit, until the middle of July, when the sorghum was too large for further cultivation.

(5) Under the head of "other items of interest" a long report might be written, which I assume you do not want, being already familiar in a general way with the methods employed in growing and harvesting the sorghum crop for the Department. I will only add a short statement in the way of a general review.

The land selected by the Commissioner was the Patterson farm, about 64 acres, adjoining the city. It is the same land that was cropped with sorghum for the Department in 1881. Last year it was not cultivated. The object in subsoiling was to guard against extremes of moisture or drought, and, the season proving an unusually wet one, it saved the crop from being washed out on the hilly portions of the field, and without it cultivation would have been impracticable during much of the early part of the growing season. The use of a concentrated fertilizer was adopted because it was not thought prudent to use raw stable manure so late in the season as would have been necessary, and a supply of decomposed manure was not obtainable. If the wet season could have been foreseen a considerable part of the ground would have been dressed with stable manure, though it is doubtful if better results would have been reached than with the fertilizer used. The varieties of cane planted were Early Amber, for the greater part, and Link's Hybrid, Honduras, Harrison's Red Top, and two others, with results not worthy of note. The Early Amber ripened first, the seed on the gravelly hill tops being ripe September 1. Honduras came next, and Link's Hybrid and Harrison's Red Top were not fully matured at the end of the season in November.

The quantity of seed returned to the Department—about 1,000 bushels—does not represent the entire yield, the depredations of the sparrows and that stolen from the field amounting to a considerable per cent. of the crop.

On the whole the results from a farmer's standpoint were satisfactory so far as the yield was concerned.

If you should require other information at my command, it will give me pleasure to furnish it.

Very respectfully,

D. M. NESBIT,
Superintendent.

Prof. H. W. WILEY,
Chemist.

WEATHER DATA.

Equally as important as the foregoing are the meteorological conditions which prevailed during the season of growth and manufacture. I append the following tables from the official records of the Signal Office. From these monthly tables the season of 1883 can be compared in mean temperatures and precipitations with those preceding it.

Meteorological summary.

MAY, 1883.

[Station: Washington, D. C.]

Date.	Daily mean barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	*°F.*	*°F.*	*°F.*	*Inches.*
May 1	30. 310	52. 1	59. 1	42. 6	....
2	30. 197	58. 4	69. 6	47. 3	....
3	30. 083	64. 3	76. 5	48. 7	....
4	30. 074	70. 0	86. 9	54. 8	....
5	30. 162	53. 0	64. 0	51. 5	0. 53
6	30. 153	58. 5	69. 2	51. 0	....
7	30. 038	64. 2	76. 3	46. 8	....
8	29. 932	74. 9	90. 2	59. 2	....
9	30. 067	70. 2	86. 0	58. 0	....
10	30. 012	71. 3	87. 0	53. 1	....
11	30. 022	65. 9	75. 0	58. 9	0. 06
12	30. 050	62. 4	72. 4	50. 8	....
13	30. 059	61. 0	72. 0	52. 9	....
14	29. 929	55. 2	59. 4	48. 4	0. 59
15	29. 684	59. 5	74. 0	55. 1	0. 16
16	30. 038	59. 7	69. 7	49. 5	....
17	30. 252	55. 6	69. 9	45. 0	....
18	30. 274	63. 4	77. 9	44. 2	....
19	30. 111	63. 3	75. 5	47. 8	....
20	29. 686	67. 2	80. 0	51. 1	....
21	29. 423	63. 8	73. 0	58. 1	0 99
22	29. 565	51. 2	58. 8	48. 3	0. 15
23	29. 848	51. 8	57. 4	47. 3	....
24	30. 044	63. 4	77. 6	48. 3	....
25	30. 078	68. 4	82. 8	49. 6	....
26	29. 835	72. 7	81. 8	59. 8	0. 01
27	29. 777	67. 6	76. 0	59. 7	....
28	29. 852	69. 9	80. 7	56. 0	....
29	29. 899	71. 9	84. 4	64. 1	....
30	29. 995	70. 3	77. 5	59. 9	....
31	30. 023	70. 2	76. 9	63. 5	0. 01
Means	29. 983	63. 6	74. 8	52. 6	0. 081

GENERAL ITEMS.

Mean barometer, 29.983; highest temperature, 9.2°, date 8th; lowest temperature, 42.6°, date 1st; greatest daily range of temperature, 33.9°, date 10th; least daily range of temperature, 10.1°, date 23d; mean daily range of temperature, 22.1°; mean daily dew point, 50.2°; mean daily relative humidity, 64.9°; prevailing direction of wind NW.; total movement of 3,987 miles; highest velocity of wind, 22 miles S. and SW. direction, date 10th and 26th.

Number of foggy days	0	Number of cloudy days	8
Number of clear days	9	Number of days on which rain fell	9
Number of fair days	14		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	63. 9	1878	62. 5
1872	67. 4	1879	65. 3
1873	63. 6	1880	70. 5
1874	63. 8	1881	67. 0
1875	63. 6	1882	59. 2
1876	64. 5	1883	63. 6
1877	61. 9		

COMPARATIVE PRECIPITATION.

	Inches.		*Inches.*
1871	3. 45	1878	5. 27
1872	1. 43	1879	1. 58
1873	5. 21	1880	3. 37
1874	2. 82	1881	1. 86
1875	1. 01	1882	5. 00
1876	3. 02	1883	2. 50
1877	2. 26		

JUNE 1883.

[Station; Washington, D. C.]

Date.	Daily mean ba-barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	°*F.*	°*F.*	°*F.*	*Inches.*
June 1	30. 332	66. 4	79. 0	54. 5	
2	30. 409	65. 9	75. 0	51. 2	
3	30. 216	66. 7	74. 7	58. 2	1. 55
4	30. 186	75. 4	87. 1	63. 5	
5	30. 154	81. 0	91. 5	67. 3	
6	30. 061	81. 6	91. 0	70. 9	
7	29. 881	79. 2	90. 1	70. 0	. 49
8	29. 914	76. 1	88. 2	68. 1	
9	29. 891	76. 4	86. 8	65. 6	. 01
10	29. 817	79. 8	92. 0	69. 1	1. 30
11	29. 792	75. 6	86. 2	65. 6	. 13
12	29. 888	76. 9	87. 4	61. 0	1. 00
13	29. 804	76. 8	86. 4	67. 4	
14	30. 188	66. 3	74. 9	60. 8	. 01
15	30. 280	67. 1	77. 2	53. 4	
16	30. 205	69. 0	80. 0	55. 1	. 03
17	30. 058	76. 4	88. 9	63. 4	. 12
18	29. 939	78. 6	87. 8	69. 4	
19	29. 792	80. 1	90. 5	69. 1	. 20
20	29. 833	76. 9	87. 3	68. 5	
21	29. 899	74. 5	85. 6	67. 3	. 77
22	29. 985	75. 1	85. 6	63. 5	
23	30. 037	73. 9	85. 3	62. 4	
24	30. 014	77. 5	89. 0	62. 2	
25	29. 917	73. 2	79. 7	69. 9	. 47
26	29. 917	71. 7	79. 9	68. 6	. 49
27	29. 874	68. 2	75. 8	66. 0	1. 71
28	29. 956	74. 6	87. 0	64. 2	
29	29. 853	75. 7	88. 2	66. 7	. 16
30	29. 900	74. 8	85. 1	61. 9	. 11
Means ..	30. 000	74. 4	84. 8	64. 2	. 285

GENERAL ITEMS.

Mean barometer, 30.000; highest temperature 92°, date 10th; lowest temperature 51.2°, date 2d; greatest daily range of temperature 26.8°, date 24th; least daily range of temperature 9.8°, date 25th and 27th; mean daily range of temperature, 20.6°; mean daily dew-points, 62.9°; mean daily relative humidity, 70.1°; prevailing direction of wind, south; total movements, 2,914 miles; highest velocity of wind and direction, 16 miles, SE. and NW.; date, 3d and 7th.

Number of foggy days	0	Number of cloudy days	6
Number of clear days	8	Number of days on which rain fell	17
Number of fair days	16		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr
1871	73. 2	1878	69. 1
1872	75. 4	1879	72. 9
1873	75. 1	1880	73. 5
1874	77. 5	1881	70. 7
1875	72. 9	1882	73. 8
1876	75. 8	1883	74. 4
1877	73. 9		

COMPARATIVE PRECIPITATIONS.

	Inches.		Inches.
1871	4. 78	1878	6. 33
1872	2. 78	1879	3. 29
1873	1. 63	1880	3. 52
1874	3. 47	1881	5. 71
1875	2. 06	1882	2. 33
1876	4. 59	1883	8. 55
1877	5. 92		

JULY, 1883.

[Station, Washington, D. C.]

Date.	Daily mean barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	° F.	° F.	° F.	*Inches.*
July 1	30. 151	69. 7	80. 9	62. 5	....
2	30. 035	81. 1	94. 1	65. 3	....
3	30. 087	84. 3	95. 0	72. 2	....
4	30. 120	83. 7	94. 0	74. 8	....
5	30. 111	80. 3	92. 8	72. 5	. 27
6	30. 066	84. 6	95. 8	72. 1	....
7	29. 912	84. 9	97. 1	73. 8	....
8	29. 859	79. 7	94. 0	67. 0	. 24
9	30. 025	68. 1	72. 2	65. 5	....
10	30. 046	72. 3	82. 9	63. 2	....
11	29. 991	77. 6	87. 6	62. 2	....
12	29. 843	73. 8	89. 0	70. 4	. 64
13	29. 811	76. 0	89. 6	66. 9	. 10
14	29. 905	77. 1	86. 9	65. 7	....
15	29. 867	79. 1	88. 0	71. 4	. 79
16	29. 980	80. 6	92. 6	68. 1	....
17	29. 996	79. 4	90. 5	72. 8	. 95
18	30. 153	74. 3	82. 4	66. 2	....
19	30. 171	71. 9	82. 3	62. 6	....
20	30. 213	70. 8	80. 0	61. 9	....
21	30. 204	77. 2	88. 5	63. 9	. 01
22	30. 126	84. 1	96. 5	72. 9	....
23	29. 990	84. 5	95. 9	77. 7	....
24	29. 785	77. 5	90. 6	67. 8	1. 00
25	29. 941	70. 4	78. 4	64. 9	....
26	30. 084	72. 8	85. 9	62. 4	. 27
27	30. 152	77. 4	88. 1	65. 6	....
28	30. 004	71. 6	81. 5	65. 2	. 46
29	30. 022	70. 6	79. 8	63. 0	....
30	30. 095	71. 2	81. 0	62. 0	....
31	30. 085	72. 9	85. 5	61. 9	....
Means	30. 027	76. 8	87. 7	67. 2	. 153

GENERAL ITEMS.

Mean barometer, 30.027; highest temperature, 97.1°, date, 7th; lowest temperature, 61.9°, date, 20th and 31st; greatest daily range of temperature, 28.8°, date, 2d; least daily range of temperature, 6.7°, date 9th; mean daily range of temperature, 20.5°; mean daily dew-point, 64.8°; mean daily relative humidity, 68.9°; prevailing direction of wind, south; total movement of, 2,756 miles; highest velocity of wind and direction, 16 miles NW. and SW., 5th and 12th.

Number of foggy days	0	Number of cloudy days	4
Number of clear days	11	Number of days on which rain fell	12
Number of fair days	16		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	74. 0	1878	80. 2
1872	81. 1	1879	78. 6
1873	79. 8	1880	76. 7
1874	78. 9	1881	77. 4
1875	77. 0	1882	76. 0
1876	81. 4	1883	76. 8
1877	77. 8		

COMPARATIVE PRECIPITATIONS.

	Inches.		Inches.
1871	6. 10	1878	8. 37
1872	0. 82	1879	3. 36
1873	4. 30	1880	2. 25
1874	2. 34	1881	1. 67
1875	3. 05	1882	4. 46
1876	5. 12	1883	4. 73
1877	6. 50		

AUGUST, 1883

[Station, Washington, D. C.]

Date.	Daily mean barometer	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	° F.	° F.	° F.	*Inches.*
Aug. 1	30.016	76.5	87.5	61.6	....
2	29.794	78.3	88.7	71.6	.03
3	29.892	74.9	83.9	67.0	....
4	30.091	69.7	80.9	58.8	....
5	30.158	73.3	82.6	61.2	....
6	30.200	69.4	80.3	61.9	....
7	30.207	69.4	81.4	58.0	....
8	30.156	70.6	82.0	56.7	....
9	30.110	69.9	81.2	58 9	....
10	30.086	69.4	78.9	60.2	....
11	30.045	70.1	80.5	58.6	....
12	30.001	72.3	85.3	58.0	....
13	30.019	77.7	91.2	64.8	....
14	30.198	72.9	78.8	69.1	.01
15	30.215	62.8	71.6	60.9	1.04
16	30.060	63.1	66.1	61.0	.38
17	30.131	69.9	79.0	57.5	....
18	30,085	78.2	90.2	66.7	....
19	30.015	79.0	91.2	69.5	....
20	29.957	82.3	93.6	68.3	....
21	30.053	80.3	89.9	72.3	....
22	30.077	78.3	92.0	65.4	....
23	29.961	79.6	92.3	68.1	1.34
24	30.016	74.5	82.2	69.1	....
25	30.082	71.0	83.0	59.7	....
26	30.101	69.8	83.0	60.4	....
27	30.226	67.8	75.7	62.2	....
28	30.047	67.9	78.0	58.2	....
29	29.894	67.0	73.7	62.6	....
30	30.070	63 1	71.7	58.7	.50
31	30.204	66.8	79.0	55.4	....
Means......	30.070	72.1	82.4	62.7	.106

GENERAL ITEMS.

Mean barometer. 30,070; highest temperature, 93.6°, date, 20th; lowest temperature, 55.4°, date, 31st; greatest daily range of temperature, 27.3°, date, 2d; least daily range of temperature, 5.1°, date, 16th; mean daily range of temperature, 19.8°; mean daily dew-point, 59.6°; mean daily relative humidity, 67.9°; prevailing direction of wind, north; total movement of 2,497 miles; highest velocity of wind and direction, 13 miles NW., date 23d.

Number of foggy days	0	Number of cloudy days	4
Number of clear days	13	Number of days on which rain fell	10
Number of fair days	14		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	76.8	1878	75.0
1872	79.0	1879	73.9
1873	74.8	1880	74.9
1874	71.6	1881	76.5
1875	71.9	1882	73.9
1876	75.5	1883	72.1
1877	76.3		

COMPARATIVE PRECIPITATIONS.

	Inches.		Inches.
1871	1.59	1878	8.89
1872	5.72	1879	7.36
1873	6.83	1880	3.83
1874	17.10	1881	1.07
1875	12.93	1882	4.44
1876	4.17	1883	3.30
1877	2.74		

SEPTEMBER, 1883.

[Station, Washington, D. C.]

Date.	Daily mean barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	°*F.*	°*F.*	°*F.*	*Inches.*
Sept. 1	30. 198	67. 9	81. 1	56. 2	
2	30. 030	66. 5	71. 4	57. 1	. 06
3	30. 095	69. 7	78. 3	61. 0	
4	30. 113	67. 8	79. 0	53. 3	
5	30. 121	66. 5	76. 1	57. 7	
6	30. 183	61. 4	76. 0	47. 6	
7	30. 013	65. 4	79. 2	48. 7	
8	30. 011	68. 0	84. 7	57. 3	
9	30. 354	56. 6	66. 0	50. 8	
10	30. 378	54. 5	64. 5	43. 6	
11	30. 170	57. 8	60. 5	52. 1	. 14
12	29. 925	60. 6	62. 9	55. 1	1. 84
13	30. 052	69. 3	78. 4	60. 6	. 04
14	30. 145	72. 3	81. 9	62. 4	
15	30. 143	74. 0	85. 2	64. 5	
16	30. 002	74. 3	85. 7	62. 5	
17	29. 922	72. 3	87. 0	67. 0	. 22
18	30. 204	61. 7	69. 2	58. 6	. 03
19	30. 289	63. 1	70. 8	58. 0	
20	30. 091	64. 6	75. 0	58. 2	
21	29. 994	65. 2	77. 8	52. 4	
22	30. 173	62. 7	66. 0	59. 7	
23	30. 117	62. 5	68. 4	56. 4	
24	29. 747	63. 0	67. 9	59. 2	1. 98
25	29. 859	62. 0	72. 4	50. 8	
26	30. 189	55. 0	65. 6	48. 5	
27	30. 125	64. 2	73. 9	49. 4	
28	30. 081	68. 9	82. 3	59. 9	
29	30. 116	64. 4	72. 9	55. 2	
30	29. 880	70. 8	83. 3	61. 5	. 02
Means	30. 091	65. 1	74. 8	56. 2	0. 144

GENERAL ITEMS.

Mean barometer, 30.091: highest temperature, 87.0°, date, 17th; lowest temperature, 43.6°, date, 10th; greatest daily range of temperature, 30.5°, date 7th; least daily range of temperature, 6.3°. 22d; range of temperature, 18.5°; mean daily dew-point, 55 9°; mean daily relative humidity, 74.3°; prevailmean daily ing direction of wind, northeast; total movement of, 2.950 miles; highest velocity of wind and direction, 17, N. E., date 12th.

Number of foggy days	0	Number of cloudy days	9
Number of clear days	10	Number of days on which rain fell	2
Number of fair days	11		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	62. 3	1878	68. 9
1872	69. 0	1879	64. 4
1873	68. 0	1880	67. 9
1874	70. 1	1881	77. 0
1875	64. 6	1882	69. 1
1876	65. 2	1883	65. 1
1877	66. 9		

COMPARATIVE PRECIPITATIONS.

	Inches.		Inches.
1871	2. 70	1878	2. 46
1872	3. 92	1879	1. 56
1873	3. 48	1880	3. 42
1874	7. 84	1881	2. 19
1875	1. 98	1882	7. 84
1876	10. 81	1883	7. 33
1877	4. 93		

OCTOBER, 1883.

[Station, Washington, D. C.]

Date.	Daily mean barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	*°F.*	*°F.*	*°F.*	*Inches.*
Oct. 1	29. 959	58. 7	66. 0	53. 6	....
2	29. 729	63. 0	73. 2	56. 5	0. 77
3	30. 124	59. 4	69. 4	50. 7	....
4	30. 350	51. 9	60. 0	45. 0	....
5	30. 370	51. 1	57. 1	45. 4	....
6	30. 289	54. 1	56. 1	50. 1	. 11
7	30. 299	54. 4	56. 7	52. 1	. 03
8	30. 331	55. 6	65. 1	49. 6	....
9	30. 293	57. 3	72. 5	44. 2	....
10	30. 176	60. 4	77. 4	47. 1	....
11	30. 131	66. 5	80. 0	49. 5	....
12	30. 116	68. 4	71. 3	64. 4	. 16
13	29. 989	73. 3	81. 0	66. 3	. 10
14	30. 023	74. 3	84. 0	66. 5	. 02
15	30. 414	50. 9	68. 0	42. 7	....
16	30. 602	44. 4	53. 0	37. 5	....
17	30. 599	48 4	55. 7	36. 2	....
18	30. 475	52. 7	59. 5	41. 0	....
19	30. 286	62. 3	70. 8	54. 3	....
20	30. 184	61. 8	71. 9	52. 4	. 20
21	30. 313	45. 5	53. 2	41. 8	. 37
22	30. 315	49. 2	51. 2	45. 0	. 01
23	30. 257	45. 6	49. 7	43. 2	. 50
24	30. 173	50. 8	60. 1	42. 8	....
25	30. 083	52. 8	61. 9	41. 8	....
26	30. 045	53. 4	60. 6	48. 1	....
27	30. 137	54. 0	61. 3	46. 6	....
28	30. 108	59. 2	66. 3	50. 6	. 01
29	29. 681	65. 5	73. 0	58. 5	. 35
30	29. 892	61. 5	71. 2	55. 5	....
31	29. 954	58. 8	73. 7	48. 9	....
Means	30. 184	56. 9	65. 5	49. 3	. 085

GENERAL ITEMS.

Mean barometer, 30.184; highest temperature, 84°, date, 14th; lowest tenperature, 36.2°, date 17th; greatest daily range of temperature, 30.5°, date 11th; least daily range of temperature, 4.6°, 7th; mean daily range of temperature, 16.2°; mean daily dew-point, 49°; mean daily relative humidity, 77°; prevailing direction of wind, north; total movement of 3,088 miles; highest velocity of wind and direction, 27, N. W.

Number of foggy days	0	Number of cloudy days	15
Number of clear days	4	Number of days on which rain fell	16
Number of fair days	12		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	58. 1	1878	57. 0
1872	65. 5	1879	62. 0
1873	54. 9	1880	54. 9
1874	55. 9	1881	62. 9
1875	53. 6	1882	60. 9
1876	50. 7	1883	56. 9
1877	58. 6		

COMPARATIVE PRECIPITATIONS.

	Inches.		Inches.
1871	1. 50	1878	5. 86
1872	4. 83	1879	0. 79
1873	5. 62	1880	2. 31
1874	0. 29	1881	3. 29
1875	1. 86	1882	0. 53
1876	2. 99	1883	2. 63
1877	6. 50		

NOVEMBER, 1883.

[Station, Washington, D. C.]

Date.	Daily mean barometer.	Temperature.			Daily rainfall.
		Daily mean.	Maximum.	Minimum.	
1883.	*Inches.*	°*F.*	°*F.*	°*F.*	*Inches.*
Nov. 1	30. 081	43. 9	52. 8	40. 3	....
2	30. 199	43. 4	47. 8	38. 1	....
3	30. 292	45. 2	53. 2	34. 8	....
4	30. 271	53. 0	67. 0	42. 3	....
5	30. 310	53. 0	66. 9	37. 4	....
6	30 072	56. 6	63. 1	50. 1	. 10
7	30. 181	50. 3	67. 9	45. 1	....
8	30 073	52. 5	60. 1	40. 7	. 05
9	29. 882	59. 4	64. 2	54. 7	. 15
10	29. 937	61. 0	72. 0	55. 8	. 08
11	29. 933	56. 4	58. 3	55. 1	. 21
12	30. 143	37. 4	56. 2	32. 8	....
13	30. 020	41. 7	49. 8	30. 1	....
14	30. 056	38. 0	50. 1	29. 3	....
15	30. 218	31. 9	40. 8	21. 8	....
16	30. 582	25. 8	33. 1	20. 8	....
17	30. 541	32. 4	41. 8	20. 8	....
18	30. 375	36. 6	52. 0	22. 1	....
19	30. 369	42. 1	58. 3	27. 1	....
20	30. 337	49. 8	59. 7	34. 1	....
21	30. 184	60. 1	65. 5	52. 1	....
22	30. 054	65. 8	71. 9	59. 6	. 01
23	30. 062	63. 5	67. 2	60. 1	. 22
24	30. 217	57. 9	64. 4	55. 1	. 02
25	30. 379	48. 9	55. 4	47. 9	....
26	30. 177	48. 6	51. 0	45. 6	. 35
27	30. 455	39. 2	49. 0	34. 6	....
28	30. 444	40. 0	50. 0	29. 3	....
29	30. 406	37. 2	43. 9	29. 8	....
30	29. 999	43. 8	53. 4	35. 1	....
Means.....	30. 208	49. 2	58. 6	41. 3	0. 04

GENERAL ITEMS.

Mean barometer, 30.208; highest temperature, 72.0°, date 10th; lowest temperature, 20.8°, date 16th and 17th; greatest daily range of temperature, 31.2°, date 19th; least daily range of temperature, 3.2°, date 11th; mean daily range of temperature, 17.4°; mean daily dew-point, 39.5°; mean relative humidity, 73.8°; prevailing direction of wind, south; total movement of 3,179 miles; highest velocity of wind, and direction, 23 N. W., 12th and 14th.

Number of foggy days	0	Number of cloudy days	10
Number of clear days	12	Number of days on which rain fell	12
Number of fair days	8		

COMPARATIVE MEAN TEMPERATURE.

	Deg. Fahr.		Deg. Fahr.
1871	42. 3	1878	45. 4
1872	42. 5	1879	45. 6
1873	40. 8	1880	40. 2
1874	44. 6	1881	47. 5
1875	41. 0	1882	42. 9
1876	45. 2	1883	49. 2
1877	46. 2		

COMPARATIVE PRECIPITATIONS.

	Inches.		*Inches.*
1871	4. 85	1878	3. 03
1872	2. 75	1879	1. 10
1873	3. 02	1880	2. 48
1874	2. 08	1881	2. 45
1875	3. 95	1882	1. 33
1876	2. 83	1883	1. 19
1877	7. 18		

COMPARISON OF TEMPERATURE AND PRECIPITATION FOR MAY, 1883, WITH THOSE OF THE TWELVE PRECEDING MAYS.

	°Fahr.
Mean temperature for May, 1883	63.6
Mean temperature for twelve preceding Mays	64.4

Seven of the twelve preceding Mays had a higher mean temperature, viz, 66.0° F. Three of them had a lower mean temperature, viz, 61.2° F. Two of them had the same mean lower temperature, viz, 63.6° F.

	Inches.
Precipitation for May, 1883	2.5
Mean precipitation for twelve preceding Mays	2.44

Seven of the twelve preceding Mays had a greater mean rainfall, viz, 3.02 inches. Five of them had a less mean rainfall, viz, 1.62 inches.

	°Fahr.
Mean temperature for June, 1883	74.4
Mean temperature for twelve preceding Junes	73.6

Four of the twelve preceding Junes had a higher mean temperature, viz, 75.9° F. Eight of them had a lower mean temperature, viz, 72.5° F.

	Inches.
Precipitation for June, 1883	8.55
Mean precipitation for twelve preceding Junes	3.86

Not one of the twelve preceding Junes had a greater rainfall.

	°Fahr.
Mean temperature for July, 1883	76.8
Mean temperature for twelve preceding Julys	78.1

Nine of the twelve preceding Julys had a higher mean temperature, viz, 79.1° F. Three of them had a lower mean temperature, viz, 75.5° F.

	Inches.
Precipitation for July, 1883	4.73
Mean precipitation for twelve preceding Julys	4.03

Four of the twelve preceding Julys had a greater mean rainfall, viz, 6.52 inches. Eight of them had a less mean rainfall, viz, 4.02 inches.

	°Fahr.
Mean temperature for August, 1883	72.1
Mean temperature for twelve preceding Augusts	75.0

Ten of the twelve preceding Augusts had a higher mean temperature, viz, 75.6° F. Two of them had a lower mean temperature, viz, 71°.7 F.

	Inches.
Precipitation for August, 1883	3.30
Mean precipitation for twelve preceding Augusts	5.16

Eight of the twelve preceding Augusts had a greater mean rainfall, viz, 6.52 inches. Four of them had a less mean rainfall, viz, 1.77 inches.

	°Fahr.
Mean temperature for September, 1883	65.1
Mean temperature for twelve preceding Septembers	68.2

Nine of the twelve preceding Septembers had a higher mean temperature, viz, 69.9° F. Three of them had a lower mean temperature, viz, 63.7° F.

	Inches.
Precipitation for September, 1883	4.33
Mean precipitation for twelve preceding Septembers	4.31

Four of the twelve preceding Septembers had a greater mean rainfall, viz, 7.85 inches. Eight of them had a less mean rainfall, viz, 2.58 inches.

	°Fahr.
Mean temperature for October, 1883	56.9
Mean temperature for twelve preceding Octobers	57.9

Seven of the twelve preceding Octobers had a higher mean temperature, viz, 60.7° F. Five of them had a lower mean temperature, viz, 54° F.

	Inches.
Precipitation for October, 1883	2.63
Mean precipitation for twelve preceding Octobers	3.03

Six of the twelve preceding Octobers had a greater mean rainfall, viz, 4.84 inches. Six of them had a less mean rainfall, viz, 1.21 inches.

	° Fahr.
Mean temperature for November, 1883	49.2
Mean temperature for twelve preceding Novembers	43.6

Not one of the twelve preceding Novembers had a higher mean temperature.

	Inches.
Precipitation for November, 1883	1.19
Mean precipitation for twelve preceding Novembers	3.18

Eleven of the twelve preceding Novembers had a greater mean rainfall, viz, 3.26 inches. One of them had a less mean rainfall, viz, 1.10 inches.

On September 10 I found the greater number of seed heads of the Early Amber cane ripe and the seed quite hard. A few of these canes were cut, the juice expressed and analyzed. The result of the analysis showed a percentage of 9.17 sucrose, and 4.83 of other sugars.

In spite of this discouraging outlook, I determined to begin operations at the mill, in order that the experimental season might be as long as possible. A few tons of cane were brought in on the 11th of September, and on the morning of the 12th I began milling.

METHOD OF OPERATIONS.

In order that the analyses might represent the average composition of the canes, the samples of juice were taken directly from the receiving tank when it was full. I was convinced that however interesting and valuable from a scientific point of view the analyses of selected canes might be, yet they would never give to the farmer and manufacturer data upon which it would be safe to base the results of large field and mill operations. I therefore considered it to be of first importance that the analytical work should represent precisely the character of the operations taking place at the mill.

WEIGHT OF CANE.

The canes unstripped were brought from the field after the seed heads, with a part of the stalk averaging about 12 inches in length, had been cut off.

WEIGHT OF JUICE.

The defecating tanks receiving the juice were two in number. In all, sixty defecations were made in the large tank and five in the small one.

The average quantity of juice received in large tank was 548 gallons, which multiplied by 60=32,880 gallons. The average quantity of juice received in small tank was 301 gallons, which multiplied by 5=1,505 gallons. In addition to this must be reckoned juice used for fermentation and other experiments, which may be estimated at 1,000 gallons. The total number of gallons of juice expressed, therefore, from the Early Amber cane is 35,385. The average specific gravity of this mill juice was 1.06, and the weight of one gallon 8.84 pounds.

The total weight of juice expressed was 35,385 × 8.84=312,803 pounds.

The percentage of juice to gross weight of cane was 41.9. The percentage of juice to net weight of cane was 312,803÷671,715=46.60.

A POOR YIELD.

The yield of juice was remarkably poor. This was due to two causes, viz: (1) The cane was crooked, broken, and tangled, so that it was almost impossible to get an even feed; and (2) the mill, built on the model of mills designed for tropical cane, was not suited to grinding the weak and yielding stalks of sorghum.

The mill was constantly choking, the canes, after passing the first rolls, becoming tangled in the "knife" and forming into a wad that would not pass the second rolls.

In order to make the mill work it became necessary to loosen the third roll somewhat, and this allowed the canes to pass without sufficient pressure.

WEIGHT OF BAGASSE.

A few experiments were made to determine the percentage of juice expressed by weighing the bagasse.

On September 14, 6,700 pounds cane gave 2,730 pounds of bagasse and 3,970 pounds of juice=59.2 per cent.

On September 27, after the rolls had been opened to allow more rapid work, 3,420 pounds cane gave 1,660 pounds of juice=47.9 per cent.

On October 1, 2,160 pounds cane gave 970 pounds juice=40.3 per cent.

On October 3, 2,360 pounds cane gave 1,200 pounds juice=50.8 per cent.

On October 5, 2,020 pounds cane gave 940 pounds juice=46.5 per cent.

Since all the juice expressed was measured, I did not think it necessary to continue these weights. Those that are given, however, only give additional emphasis to the results obtained by measuring the juice.

AVERAGE YIELD OF SINGLE MILLING.

With a three-roll mill, especially adapted to working sorghum, I think a yield of 55 to 60 per cent. in weight of juice is all that can be expected with unstripped canes. In 1882 the Lafayette Sugar Company, in fifteen weighings of cane and bagasse, showed a yield on clean cane of 65 per cent. But this is higher than can generally be expected. As a result of several years of observation and experience, I am convinced that the average yield of three-roll mills on unstripped cane of all kinds does not exceed 50 per cent. By double milling, with intervening steaming or moistening with hot water, much better results are obtained.

Unfortunately no exact data of the working of such mills are at hand, and I can but regard as extravagant the statements which have been made which claim a yield of 75 to 80 per cent. of the weight of the cane milled in juice. Experiments in this division have shown that sorghum cane contains of water and substances soluble therein about 89 per cent. of its weight.

A perfect extraction of the juice by milling, therefore, would give 89 pounds juice to each 100 pounds of cane. It is needless to add that no system of milling now in use comes near realizing this ideal yield.

PERCENTAGE OF JUICE EXTRACTED.

The weight of juice extracted by the mill was 41.9 per cent. of the weight of the cane ground.

CANE WORKED FOR SUGAR.

Of the total weight of 746,350 pounds of amber cane, all but 174,000 pounds were worked for sugar. The quantity of juice boiled for sugar was 572,350×41.9=239,814 pounds. The percentage of sucrose in this juice determined by the mean of the analyses of each tankful was 8.77.

The sugar not sucrose (invert sugar, optically inactive sugar, and other substances reducing the alkaline copper tartrate mean of all the analyses) was 4.00 per cent. Total sugars=12.77 per cent. Total solids=14.14 per cent. Solids not sugars=1.37 per cent. Coefficient of purity=62.

It will be of interest to compare these results with the analyses of ripe Amber canes made in this division during the years 1882, '81, '80, and '79.

	Per cent.
For 1879, the average of sucrose (14th stage*) was	12.44
For 1879, the average of other sugars was	1.16
For 1880, the average of sucrose (1,127 analyses†) was	13.85
For 1880, the average of other sugars was	1.64
For 1881, the average sucrose (59 analyses) was	15.29
For 1881, the average of other sugars was	1.62
For 1882, the average of sucrose was	10.48
For 1882, the average of other sugars was	1.33
For 1883, the average of sucrose (137 analyses) was	8.77
For 1883, the average of other sugars was	4.00

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*Ag. Rept., 1880, '81, p. 452.

†Ag. Rept., 1880, '81, p. 493.

The striking inferiority of the canes of this season is at once apparent. It appears to be due to the cold season, especially in August and September, and to the fact that the whole field was prostrated by the storm of September 11 and 12.

To make crystallized sugar out of such an unpromising juice was an almost hopeless undertaking.

While I am sorry that the meager yield of sugar has been a disappointment, not only to you and the friends of the industry throughout the country, but also to this division, yet I do not see how, with the character of the cane, and the method employed, it could well have been greater.

MANUFACTURE.

The method of manufacture was an extremely simple one. As the juice flowed from the mill bisulphite of lime solution* was allowed to drop into it, about 1 quart to each 100 gallons of juice.

The object of adding the bisulphite of lime is to prevent fermentation. Raw sorghum juice, in a very short time after it is expressed, will begin to change unless some measures are taken to prevent it. Instead of the lime bisulphite the juice may be brought at once, on coming from the mill, into contact with sulphurous dioxide (sulphur fumes).

The bisulphite method has this advantage, viz., the quantity of sulphur introduced is under complete control, and can be varied to suit the quality of the juice at hand.

Arriving at the defecating tank,† the juice was heated to about 60° to 70° C. (125° to 140° F.). The steam was then turned off and milk of lime (specific gravity, 15° B.) added, with constant stirring until litmus paper showed exact neutrality. The temperature was then rapidly raised to the boiling point, but the liquid was not allowed to boil. After five minutes the scum was removed and the liquid allowed to flow through bag filters into a receiving tank below. Thence it was pumped into a large concentrator, and the steam turned on gently, so that the foam would come nearly to the top of the pan. This foam was now swept off (into a gutter running around the pan) until it became perfectly white and clean.

The steam was now turned off until the foam settled, and then turned

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* *Analyses of lime bisulphite employed.*

	1.	2.	3.	4.
Specific gravity	1.0718	1.0788	......	1.0755
Per cent. of lime	2.11	2.28	40.32	0.82
Per cent. of SO_2	5.85	6.40	23.04	6.47

No. 3 was a solid lime compound; the others were liquid.

† Dimensions of tank: length, 59.5 inches; width, 42 inches; average depth of juice, 33 inches; heating surface, 79 square feet, 2 inches copper pipe.

on with a full head, so as to at once throw the whole mass into violent ebullition.

For this end the pressure of the steam ought not to be less than four atmospheres (60 pounds).

The boiling was continued until the sirup marked 20° B. while still hot. It was then dropped into a receiving tank, whence it was sucked up into the vacuum pan and concentrated to 44° to 45° B.

With juice of this kind I found it impossible to "boil to grain," although many faithful attempts were made. It was not difficult to start the crystals, but with a sirup so poor in sucrose and so rich in other sugars it was quite impossible to nourish them.

When sufficiently concentrated the mass was dropped into wagons holding three hectoliters (85 gallons) and placed in the crystallizing room.

This room was kept at a temperature of 40° C. (106° F.), and after five to ten days the crystallization was complete and the melada ready for the centrifugal. The sugar made in this way, while of course raw, nevertheless had a nice yellow color and an agreeable flavor.*

CANE WORKED FOR SIRUP.

The cane which was harvested from September 29 to October 3, inclusive, was so very poor in quality that no attempt was made to crystallize the juice.

The total weight of this cane was 174,000 pounds; its content of sucrose was 6.73 per cent., and of other sugars 6.16 per cent.

	Per cent.
Total sugars	12.89
Total solids	13.64
Solids not sugar	.76
Coefficient of purity	50.00

Since long experience has shown that substances other than sucrose in solution prevent their equal weight of sucrose from crystallizing, it is apparent that in such a juice all hope of obtaining crystals must end in disappointment.

The quantity of sirup made from the 174,000 pounds cane was 1,104 gallons. The weight per gallon was 11.5 pounds.

Total weight sirup made, 1,104×11.5=12,696 pounds. Number of gallons of sirup per ton of cane, 12.7. The sirup is of fine flavor, but rather dark in color, owing to using lime to exact neutrality.

NOTES ON RESULTS OF WORK.

1. Single milling, *i. e.*, passing canes through one three-roll mill, gives so poor a yield that it will have to be abandoned for sorghum working.

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* The weight of sugar made from 572,350 pounds of cane was 7,160 pounds, or 1.24 per cent.

The per cent. of sugar obtained from the expressed juice was 7,160 × 100 ÷ (572,350 × .419) = 2.99.

If 60 per cent. juice had been expressed the yield would have been 35.7 pounds per ton of cane.

Tropical canes seem to mill better than the stalks of sorghum, and single milling of such canes may continue to prove profitable. It is evident, however, to every practical worker that a system of expression which gives only 45 to 50 per cent. of the total juice of the cane is too wasteful to meet the continued approval of farmers and manufacturers.

Double milling is doing much to remove this difficulty. This division has made only a few experiments with double milling, and these show a yield of nearly 65 per cent. of weight of cane. In the establishments where this process has been used only estimates have been made of its efficiency. These estimates, however, may be wide of the truth. I think, however, we may safely say that double milling increases the yield of juice 10 to 15 per cent.

2. The soil in the vicinity of Washington is not suitable to the growth of sorghum cane. It is true the yield of cane this season was far better than it has ever been heretofore since the Department undertook experiments with cane-raising in this locality. When, however, careful planting and cultivation and liberal fertilizing, combined with a fairly favorable season for growth, fail to produce 10 tons of cane per acre, it must be admitted that there is a radical defect of soil. The climate of Washington, however, is peculiarly favorable to cane growth. Early springs, warm summers, and late falls are all that the practical cane-grower could demand.

A sandy loam appears to be the most favorable soil for cane. Yet, it should not be forgotten that sorghum is a hardy plant; it will grow even under the most unfavorable conditions, and rarely proves a complete failure.

3. Manufacturers and intending manufacturers should not base their calculations for the yield of sugar on working canes containing 12 per cent. sucrose and only 1.5 to 2.0 per cent. of other sugars. I doubt whether any field of sorghum of 10 acres extent has ever been raised which would give such an average result. In the present state of the industry it would be much safer to count on 9.0 per cent. sucrose, 3.0 per cent. other sugars, and 2.0 per cent. solids not sugar, as an average of the crop from year to year.

I think this division would be guilty of a great public wrong were it by any kind of select results or enthusiastic coloring to induce capitalists to invest money where they would be led to expect a higher return than the actual facts warrant.

The results of the analyses made this year, poor as they are compared with those of former years, may nevertheless prove of great advantage to those who are proposing to practically engage in the sorghum-sugar industry by causing them the more carefully to consider all the difficulties which they will have to meet.

EFFECT OF THE STORM OF SEPTEMBER 11 AND 12 ON THE CANE.

The violent northeast storm which occurred at the beginning of the working season completely prostrated the Amber cane. The heads of

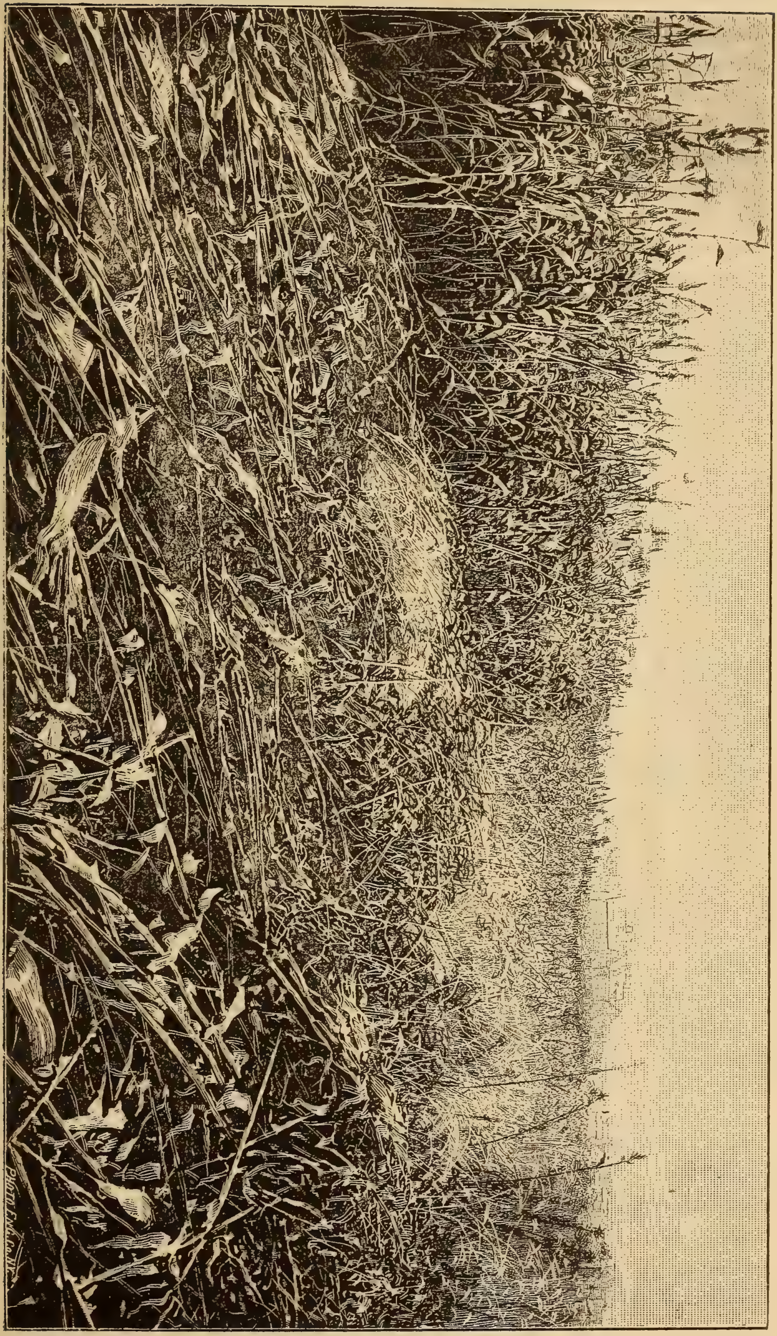
PHOTO.ENG.CO.N.Y.

FIG. 4.—Effect of storm, September 11 and 12.

this variety of cane were heavy. As soon as the ground was softened by the rain the stalks could no longer resist the force of the wind.

The illustration shows how the ripe cane was prostrated, while a less ripe variety was left uninjured.

The Amber canes were so nearly mature that they had no power of recuperation and remained prostrate. A few stalks only of the Amber remained standing. Ten days after the storm a few of these canes were collected for analysis. For comparison the same number of fallen canes were taken at the same time and from the same locality. The fallen and standing canes were as nearly alike in size and general appearance as a careful selection could make them. On October 8 another similar collection was made.

The results of the analyses of these canes are found in the appended table:

Comparative analyses of fallen and standing canes, illustrating effect of wind storm on canes.

No. of analysis.	Date.	Condition of cane.	Specific gravity.	Total solids.	Sucrose.	Other sugars.	Total sugars.	Albuminoids.	Ash.	Coefficient of purity.	Available sugar.	Number of canes.
	1883.			*Per ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
1	September 20	Standing	1.0692	15.665	11.84	3.12	14.96	......	.543	75.7	8.01	15
2	do	Down	1.0662	14.501	10.45	3.80	14.25	.213	.448	72.0	6.40	15
3	September 21	Standing	1.0708	16.758	11.88	3.01	14.89	.256	.617	71.0	7.00	25
4	do	Down	1.0571	13.359	8.39	3.64	12.03	.244	.541	62.6	3.37	25
5	October 8	Standing	1.0734	17.074	11.99	2.76	14.75	......	.475	70.2	6.91	6
6	do	Down	1.0660	15.775	10.34	3.80	14.10	......	.436	65.5	4.90	6

No. of analysis.	Date.	Condition of cane.	Total weight.	Weight of clean canes.	Weight of heads.	Weight of blades.	Weight of bagasse.	Per cent. of heads.	Per cent. of blades.	Per cent. of juice.
	1883.		*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*			
1	September 20	Standing	9.280	6.992	1.477	.812	2.339	15.9	10.5	70.1
2	do	Down	9.550	7.236	1.359	.956	2.350	14.2	11.7	67.5
3	September 21	Standing	10.433	7.796	1.609	.924	2.790	15.5	10.6	64.2
4	do	Down	......	6.024	1.446	.698	2.060	......	10.4	65.8
5	October 8	Standing	3.260	......	......	......	1.400	......	......	......
6	do	Down	2.560	......	......	......	1.020	......	......	......

The above analyses show that the effect of leveling the canes is most disastrous. The percentage of available sucrose was diminished by at least two units from the effect of the storm. Inasmuch as the percentage of available sugar in the juices worked was, in round numbers, three, it is seen that had there been no storm the amount of sugar made from the cane would have been nearly doubled.

In all localities subject to equinoctial storms the above figures will be of considerable interest.

ANALYTICAL RESULTS.

In the following tables will be found the analytical data derived from the analyses of samples of raw and defecated juices and semi-sirup, taken in the manner already described from the large tanks during the process of manufacture.

In Table III each semi-sirup represents the whole of the juice operated on from the preceding date in table No. I.

Thus the analysis No. 3, Table III, is a semi-sirup made from juice represented by analysis No. 1, Table I; No. 6, Table II, is from No. 4, Table I, &c.

TABLE I.—*Analyses of raw juices taken from receiving tank.*

No. of analyses.	Date.	Specific gravity.	Per cent. total solids.	Per cent. total sugars.	Per cent sucrose by direct polarization.	Per cent. sucrose by double polarization.	Per cent. average of other sugars.	Coefficient of purity.	Per cent. of ash.	Per cent. of nitrogen.	Per cent. of albuminoids.	Per cent. of nitrogen as amides.
1	Sept. 12	1.0573	13.72	12.60	9.50	9.28	3.32	67.6	.4100	......	......	......
4	Sept. 13	1.0591	14.27	12.68	9.50	8.68	4.00	60.8	.3300	......	......	......
8	Sept. 14	1.0578	13.80	12.74	9.75	9.11	3.63	66.0	.3700	......	......	......
10	Sept. 14	1.0599	14.55	13.06	10.20	9.48	3.58	65.1	.4400	......	......	......
12	Sept. 15	1.0625	14.96	13.39	10.35	9.49	3.90	63.4	.5300	......	......	......
15	Sept. 15	1.0608	14.56	13.28	10.00	9.27	4.01	63.6	.5300	......	......	......
18	Sept. 17	1.0658	15.54	12.85	9.15	7.10	5.75	45.6	.6000	......	......	......
20	Sept. 17	1.0614	14.45	12.51	8.25	8.33	4.18	57.6	.6000	......	......	......
23	Sept. 18	1.0612	14.40	12.17	9.70	8.09	4.08	56.1	.6205	......	......	......
25	Sept. 18	1.0551	13.08	10.30	7.30	6.95	3.35	53.1	.5870	......	......	......
28	Sept. 18	1.0571	13.02	11.79	8.75	8.31	3.48	63.8	.6250	......	......	......
33	Sept. 19	1.0596	12.97	12.53	....	9.43	3.10	72.5	.7151	......	......	......
42	Sept. 25	1.0587	13.73	12.16	9.20	8.59	3.57	62.5	.4129	.021	.131	......
45	Sept. 26	1.0671	15.71	14.53	10.90	10.64	3.89	67.7	.4577	.016	.100	......
48	Sept. 26	1.0634	14.84	13.97	10.50	10.23	3.74	68.9	.4799	.025	.158	......
52	Sept. 27	1.0655	15.47	13.94	10.00	10.00	3.94	64 7	.5064	.017	.106	......
55	Sept. 27	1.0622	14.80	13.04	9.50	9.14	3.90	61.7	.5739	.022	.139	......
58	Sept. 27	1.0624	14.63	12.60	10.05	9.44	3.16	64.5	.5924	.023	.146	......
61	Sept. 28	1.0649	15.40	13.94	10.25	9.80	4.14	63.6	.9841	......	......	......
64	Sept. 28	1.0579	13.65	12.85	8.30	8.14	4.71	59.6	....	......	......	......
67	Sept. 29	1.0657	15.17	14.30	5.30	6.34	7.96	41.7	1.9433	......	......	......
69	Sept. 29	1.0653	15.32	12.79	7.65	7.21	5.58	47.1	.4436	......	......	......
71	Sept. 29	1.0604	12.80	13.62	7.85	8.31	5.31	64.9	.3614	......	......	......
73	Oct. 1	1.0655	15.41	16.63	7.00	8.11	8.52	52.6	.4537	.034	.213	65.9
76	Oct. 1	1.0655	15.41	12.85	3.65	5.06	7.79	32.8	.4417	.026	.163	72.2
78	Oct. 1	1.0591	12.80	11.30	3.55	5.00	6.30	39.0	.5023	.031	.191	75.9
80	Oct. 2	1.0524	12.01	11.28	5.75	6.37	4.91	53.0	.4954	......	......	......
83	Oct. 3	1.0520	12.22	10.86	5.70	6.04	4.82	49.4	.5494	......	......	......
85	Oct. 3	1.0515	12.20	11.37	6.65	7.03	4.34	57.6	.4567	......	......	......
87	Oct. 3	1.0554	13.09	11.93	7.85	7.78	4.15	59.4	.4980	......	......	......
89	Oct. 4	1.0589	13.77	12.39	8.50	8.21	4.18	59.6	.4667	......	......	......
91	Oct. 4	1.0577	13.42	12.26	7.85	8.03	4.23	59.9	.4461	......	......	......
94	Oct. 4	1.0595	14.06	12.73	8.85	8.75	3.98	62.2	.4283	......	......	......
96	Oct. 5	1.0595	14.38	12.68	9.00	8.71	3.97	60.5	.4568	......	......	......
98	Oct. 5	1.0633	15.29	13.27	10 60	10.15	3.12	66.3	.6025	......	......	......
100	Oct. 5	1.0656	15.41	13.91	11.40	10.91	3.00	70.7	.6944	......	......	......
103	Oct. 6	1.0626	14.89	12.63	10.30	9.98	2 65	67.0	.5882	......	......	......
105	Oct. 6	1.0657	15.77	14.17	11.00	10.68	3.49	67.7	.5358	......	......	......
107	Oct. 6	....	....	14.23	11.25	11.00	3.23	....	...	......	......	......
109	Oct. 8	1.0576	13.73	12.54	8.70	8.59	3.95	62.5	.4851	.024	.150	80.2
111	Oct. 8	1.0585	13.82	12.22	8.70	8.28	3.94	59 9	.4932	......	......	......
113	Oct. 9	1.0523	12.56	11.50	7.65	7.67	3.83	61.0	.6130	.028	.175	96.1
115	Oct. 9	1.0549	13.22	11.74	7.80	7.81	3.93	59.0	.6778	......	......	......
117	Oct. 9	1.0565	13.75	12.20	8.10	8.12	4.08	59.0	.4733	......	......	......
119	Oct. 10	1.0559	13.37	11.96	8.10	8.14	3.82	60.8	.4855	.019	.119	63.2
121	Oct. 10	1.0510	12.15	10.82	6.15	6.33	4.49	52 1	.7943	......	......	......
123	Oct. 10	1.0505	11.65	10.56	6.25	6.37	4.19	54.5	.7949	......	......	......
125	Oct. 11	1.0623	14.78	13.27	9.55	9.39	3.88	63.5	.5117	.024	.150	46.3
127	Oct 11	1.0622	14.70	13.41	9.75	9.69	3.72	65.9	.6097	......	......	......
129	Oct. 12	1.0632	15.05	12.37	8.10	8.19	4.18	54.4	.6067	.031	.194	72.4
131	Oct. 12	1.0621	14.17	13.07	7.75	7.93	5.14	55.9	.4928	......	......	......
134	Oct. 13	1.0566	13.00	11.79	6.40	6.71	5.08	51.6	.6623	.029	.181	59.4
	Average.	1.0598	14.06	12.68	8.72	8.38	4.09	59.2	.5685	.0246	.1544	70.2

TABLE II.—*Analyses of defecated juices taken from receiving tank.*

[N. B.—Each number in the following table represents the raw juice designated by the next preceding number of Table I; thus No. 65 of this table is from the same tank as No. 64 of Table I.]

No. of analyses.	Date.	Specific gravity.	Per cent. total solids.	Per cent. total sugars.	Per cent. sucrose by direct polarization.	Per cent. sucrose by double polarization.	Per cent. average of other sugars.	Coefficient of purity.	Per cent. of ash.	Per cent. of nitrogen.	Per cent. of albuminoids.	Per cent. of nitrogen as amides.
2	September 12 ...	1.0589	14.21	12.28	9.50	9.10	3.18	64.0	....	......	....	......
5	September 13 ...	1.0617	14.69	13.29	9.35	9.28	4.01	63.2	....	......	....	......
9	September 14 ...	1.0604	14.34	12.76	9.65	9.04	3.72	63.0	.4300	......	....	......
11	September 14 ...	1.0623	15.05	13.68	10.60	9.91	3.77	65.8	.4900	......	....	......
14	September 15 ...	1.0580	13.71	12.91	10.50	9.28	3.63	67.6	.7000	......	....	......
16	September 15 ...	1.0655	14.44	13.40	10.50	9.43	3.97	65.3	.7100	......	....	......
19	September 17 ...	1.0671	15.66	14.44	9.15	8.45	5.99	53.9	.4200	......	....	......
21	September 17 ...	1.0627	15.60	13.46	10.00	8.89	4.57	56.9	.7100	......	....	......
24	September 18 ...	1.0633	14.81	12.57	9.25	8.51	4.06	57.4	.6017	......	....	......
27	September 18 ...	1.0597	14.11	11.26	8.50	7.86	3.40	55.7	.6110	......	....	......
29	September 18 ...	1.0576	13.67	11.62	9.35	8.13	3.48	59.4	.6120	......	....	......
34	September 19 ...	1.0614	14.46	12.95	......	9.73	3.22	67.2	.6821	.019	.1190	......
36	September 22 ...	1.0679	15.71	14.28	7.55	7 96	6.32	50.6	.7669	.032	.2000	......
43	September 25 ...	1.0609	14.18	12.98	9.35	8.88	4.10	62.6	.4973	.011	.0680	......
46	September 26 ...	1.0675	15.78	15.39	10.95	11.58	3.81	73.3	.4920	.027	.1710	..
49	September 26 ...	1.0688	16.05	14.17	11.10	10.36	3.81	64.5	.5539	.017	.1050	......
53	September 27 ...	1.0685	15.87	14.16	10.65	10.28	3.88	64.7	.6173	.023	.1460	......
56	September 27 ...	1.0660	15.41	13.62	10.15	9.94	3.68	64,5	.5854	.017	.1050	......
59	September 27 ...	1.0657	15.25	13.42	10.36	10.36	3.06	67.9	.6364	......	....	......
62	September 28 ...	1.0669	15.56	14.47	10.60	10.64	3.83	68.3	.7028	......	....	......
65	September 28 ...	1.0611	14.05	12.64	8.45	8.16	4.49	58.0	.5247	......	....	......
68	September 29 ...	1.0681	15.70	15.23	6.60	8.43	6.80	53.6	.4820	......	....	......
70	September 29 ...	1.0706	16.43	14.30	7.90	7.90	6.46	48.0	.5494	......	....	......
74	October 1	1.0684	16.00	16.90	7.55	8.41	8.49	52.5	.4907	.024	.1500	93.5
77	October 1	1.0688	15.80	13.12	4.50	5.96	7.16	37.7	.4732	.022	.1375	90.5
81	October 2	1.0537	12.32	11.74	5.75	6.85	4.89	55.6	.5258	......	....	......
84	October 3	1.0545	12.88	11.23	6 30	6.44	4.79	50.0	.4444	......	....	......
86	October 3	1.0533	12.55	11.36	7.00	7.18	4.18	57.2	.3987	......	....	......
88	October 3	1.0569	13.30	12.06	8.45	8.18	3.88	61.5	.4386	......	....	......
90	October 4	1.0601	14.12	12.34	8.00	8.21	4.13	58.1	.4245	......	....	......
92	October 4	1.0635	15.00	13.66	9.30	9.23	4.43	61.5	.4656	......	....	......
97	October 5	1.0622	14.86	13.15	9.15	9.00	4.15	67.3	.5244	......	....	......
99	October 5	1.0654	15.57	13.83	10.65	10.38	3.45	66.6	.6354	......	....	......
101	October 5	1.0680	15.68	13 88	10.05	10.81	3.07	68.9	.7105	......	....	......
104	October 6	1.0675	15.83	14.07	10.50	10.34	3.73	65.3	.6923	......	....	......
106	October 6	1.0681	15.99	14.32	11.20	10.91	3.41	68.2	.5926	......	....	......
108	October 6	1.0693	16.30	14.57	11.50	11.16	3.41	68.4	.6350	......	....	......
110	October 8	1.0613	14.53	13.15	9 25	9.14	4.01	62.9	.5258	.022	.1375	88.3
112	October 8	1.0599	14.27	12.42	8.95	8.69	3.73	60.9	.5274	......	....	......
114	October 9	1.0534	12.74	11.23	7.55	7.48	3.75	58.7	.5459	.015	.0938	86.0
116	October 9	1.0565	13.30	11.89	8.25	8.16	3.73	61.3	.5452	......	....	......
118	October 9	1.0577	13.71	12.34	8.35	8.30	4.04	60.5	.5105	......	....	......
120	October 10	1.0575	13.47	11.89	8.20	8.30	3.59	61.6	.5248	.016	.1000	87 0
122	October 10	1.0504	11.97	11.04	6.50	6.62	4.42	55.3	.5084	......	....	......
124	October 10	1.0513	11.95	11.25	6.85	7.01	4.24	58.6	.4669	......	....	......
126	October 11	1.0630	14.88	13.02	9.35	9.28	3.74	62.3	.5212	.019	.1188	100.0
130	October 12	1.0642	15.14	13.38	8.75	8.88	4.50	58.6	.6174	.020	.1250	84.2
132	October 12	1.0674	15.55	14.01	9.10	9.00	5.01	57.8	.6442	......	....	......
133	October 12	1.0694	14.51	10.48	9.20	8.45	2.03	58.2	1.5411	......	....	......
135	October 13	1.0568	13.13	11.76	6.50	6.68	5.08	50.8	.4883	......	....	......
	Average	1.0623	14.60	13.06	8.91	8.62	4.32	60.4	.5790	.020	.1269	89.9

TABLE III.—*Analyses of semi-sirups from Amber cane.*

No. of analyses.	Date.	Specific gravity.	Per cent. total solids.	Per cent. total sugars.	Per cent. sucrose by direct polarization.	Per cent. sucrose by double polarization.	Per cent. average other sugars.	Coefficient of purity.	Per cent. of ash.
3	September 13	1. 2974	60. 13	48. 43	35. 0	33. 14	15. 29	55. 1	....
6	September 13	1. 2618	54. 00	47. 37	33. 0	31. 53	15. 84	56. 5	....
13	September 15	1. 2995	60. 07	54. 48	40. 0	38. 68	15. 80	64. 4	....
17	September 15	1. 2294	47. 77	42. 56	31. 8	30. 04	12. 52	62. 9	....
22	September 18	1. 2780	55. 70	53. 01	32. 9	32. 04	20. 97	57. 5	....
31	September 18	1. 2538	53. 09	45. 84	....	31. 78	14. 06	59. 9	....
35	September 19	1. 3022	59. 35	55. 67	41. 4	40. 53	15. 14	68. 3	....
40	September 24	1. 2219	53. 48	45. 50	15. 7	19. 73	25. 77	36. 9	1. 6966
44	September 26	1. 3081	60. 87	56. 28	36. 0	35. 54	20. 74	58. 4	2. 2343
47	September 26	1. 1922	40. 84	36. 47	26. 3	25. 60	10. 87	62. 7	1. 2600
50	September 26	1. 2849	57. 14	49. 86	35. 5	34. 11	15. 75	59. 7	....
54	September 27	1. 2263	47. 24	41. 09	30. 7	28. 29	12. 80	59. 7	....
57	September 27	1. 2954	59. 37	50. 01	37. 0	35. 70	14. 31	60. 1	2. 2626
60	September 27	1. 2687	54. 62	47. 57	36. 3	34. 80	12. 77	63. 7	....
63	September 28	1. 2382	49. 02	45. 20	....	33. 49	11. 71	68. 1	....
66	September 28	1. 2886	56. 75	50. 80	32. 6	32. 53	18. 27	59. 0	....
72	September 29	1. 2744	54. 39	50. 23	27. 5	29. 63	20. 60	54. 5	1. 7700
75	October 1	1. 1992	41. 72	38. 01	14. 0	16. 41	21. 60	39. 3	1. 2217
79	October 1	1. 2302	47. 18	41. 07	13. 1	17. 66	23. 41	37. 4	1. 3183
82	October 2	1. 2282	46. 97	41. 23	19. 4	22. 13	19. 10	47. 2	1. 9540
95	October 5	1. 2701	55. 37	48. 33	32. 0	32. 40	15. 93	58. 5	1. 7300
102	October 5	1. 2676	54. 19	49. 81	35. 9	35. 64	14. 17	65. 8	2. 3643
136	October 15	1. 2035	43. 13	36. 95	26. 0	26. 11	10. 84	60. 6	1. 6066
137	October 15	1. 2237	46. 62	40. 20	24. 1	24. 79	15. 41	53. 2	1. 7260
	Average	1. 2559	52. 478	46. 50	29. 83	30. 08	16. 28	57. 1	1. 7620

CONCLUSIONS FROM TABLE I.

The best Amber juice of the season was obtained September 19, analysis No. 30.

The substances in solution in this juice, aside from the sugars, were only .44 per cent.

No. 107 might have proved a better juice, but the data for computation are not complete.

Direct polarization gave a mean result (viz, 8.72 per cent.) somewhat higher than that of double polarization (viz, 8.38). This shows that there was present in the juice dextrogyratory matter not sugar (viz, soluble starch, gum, &c.) more than enough to counteract the lævo-rotatory power of the invert sugar present.

The error which may arise from relying on a single polarization is illustrated by such analyses as Nos. 18, 23, 42, &c., in which the first polarization gives results too high; and in Nos. 67, 73, 76, 78, 80, &c., in which the results are too low.

In cane, ripe and lately harvested, the results of single polarization are quite reliable. In injured or long-harvested canes they are too low. In canes containing large quantities of starch and gum they are too high.

CONCLUSIONS FROM TABLE II.

As is to be expected the effect of defecation on the juices is to increase the percentage of ash, this being in Table I, .5685, and in II, .579.

This small increase shows, however, that most of the lime added in defecation was removed in the sediments formed and by filtration through bags, since the concentration which takes place in defecation is almost sufficient to account for the increase.

The results of single and double polarization agree more closely than in Table I, being 8.91 per cent. and 8.62 per cent. respectively.

The process of defecation therefore has removed a great deal of the substances (starch, gum, invert sugar) which disturb polarization.

The increase in the percentage of sucrose is due to the concentration already alluded to.

The increase in uncrystallizable sugar (from 4.09 to 4.32) is greater than can be reasonably accounted for by concentration.

The coefficient of purity was raised by defecation from 59.2 to 60.4. This increase was not as great as was expected, nor so much as was secured by carbonatation as described further on.

CONCLUSIONS FROM TABLE III.

In as much as the juices were reduced to semi-sirup in an open pan it will be of interest to study the effect of this proceeding on the inversion of the sucrose.

The ratio of anoptose, &c., in Table II to sucrose by double polarization is

$$4.32 : 8.62 = 1 : 1.995.$$

In the semi-sirups it is

$$16.28 : 30.08 = 1 : 1.848.$$

It is thus seen that a considerable loss of sucrose has occurred by inversion. This confirms the results of double polarization which show that there is much more invert sugar in the semi-sirup than in the juices.

These results give additional emphasis to the fact that sugar juices, immediately after defecation, should be concentrated in a vacuum.

AMBER CANE GROWN IN INDIANA.

In order to determine the influence of soil and climate on the sugar product of cane, the Lafayette Sugar Company, Wea, Ind., engaged to plant and cultivate five acres of early Amber cane for the Department of Agriculture, to work the same to a semi-sirup weighing 25° B. hot; to put the same in barrels and send to Washington.

The soil in which the cane was grown was a light sandy loam, with gravel, then clay subsoil, and quite hilly.

On the top of the hills the soil was full of gravel and quite unproductive. The field had been in cultivation fifteen years, mostly in corn, and had never had any fertilizer of any kind. The average yield of corn on the patch put in cane had been about 20 bushels per acre. The ground was plowed with a common two-horse plow, and harrowed. The cane seed was drilled in rows 3½ feet apart on the 3d of May.* The seed had been previously steeped in tepid water for forty-eight hours. The plants generally came up in a week. The young plants suffered much from cold, wet weather. The cane received two hoeings and three plowings, with double sulky cultivator. There was a heavy frost the morning of May 31, injuring the young plants somewhat.

Meteorological data from the official records of Purdue University, seven miles from cane-field, Wea, Ind.

Months, 1883.	Mean pressure.	Temperatures.			Mean relative humidity.	Total rain and melted snow.	Wind.		
		Mean.	Max.	Min.			Total.	Daily.	Hourly.
	Inches.	°	°	°		*Inches.*	*Miles.*	*Miles.*	*Miles.*
May	30.000	58.42	82.	42.		4.29	5,902.	210.70	8.78
June	29.990	65.36	80.	54.		4.96	5,720.	220.00	9.16
July	30.093	71.53	89.	58.		4.68	5,272.	170.06	7.08
August	30.131	68.75	89.	55.		1.77	3,565.	142.60	5.94
September	30.471	61.22	87.	32.	74.26	1.46	4,986.	184.66	7.69

Mr. Deming, the superintendent, writing under date of August 3, says:

> The season has been remarkable for the number of heavy rainfalls, accompanied with strong winds, damaging the cane considerably. At 2 p. m. this day the thermometer registered 39°.

During the latter part of September I went to the company's works at Wea (West Point post-office), Ind., to superintend the working of this cane into semi-sirup, which was done on the 1st and 2d of October. The method employed was the same as has been described for the cane here, with the exception that the juice as it left the mill passed through a sulphur box, where it was thoroughly mixed with the fumes of burning sulphur. This removed the necessity of allowing the lime bisulphite to run into the juice as it left the mill, and this chemical was therefore added first when the juice reached the defecator.

PRODUCT OF CANE, ETC.

A heavy rain and wind storm on the night of September 29 had completely prostrated the cane, and the whole of it was gathered and weighed very wet. I therefore made a deduction of 2½ per cent. for this increase of weight.

Wet cane	tons	48.
Less 2½ per cent	do	46.8
Clean cane (estimated)	do	42.
Juice expressed	gallons	5,309.
Specific gravity	degrees B	7.95

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*About one acre of this which did not make a good stand was replanted the last week in May.

Temperature	degrees F..	68.8
Weight of juice expressed	pounds..	46,932.
Juice expressed (gross weight cane)	per cent..	50.
Juice expressed (net weight cane)	do...	55.9

The mill used was Squeir's No. 2 Louisiana.

The semi-sirup made amounted to 1,014 gallons, measured cold; specific gravity, 27° B.=1.225. One gallon, therefore, weighs 10.17 pounds; total weight, 1,014 gallons=10,312 pounds.

This semi-sirup was put in barrels and sent to Washington by freight. It arrived there on October 25, and was immediately boiled in the vacuum-pan.

The crystals were easily started in the pan, and grew to full size in about ten hours.

The melada was ready for the centrifugal as it came from the pan, and some of it was swung directly from the pan, yielding 50 per cent. of good sugar.

I did not succeed in "boiling to grain" with any other sirup except these two "strikes" from the Indiana cane.

SUGAR OBTAINED.

The weight of sugar obtained from the Indiana cane was 2,860 pounds. This gives a percentage of 3.39 on clean cane ground and 6.09 per cent. of the weight of juice expressed.

The result of the experiment with the Indiana cane was in every way encouraging, and served in a manner to diminish the disappointment which attended the work in other directions.

A yield of over 60 pounds of sugar to the ton when only 50 per cent. of the weight of cane was obtained in the expressed juice is an indication of what may be obtained in the future with better milling or a more thorough extraction of the sugar by other methods.

ALALYSES OF CANES, SIRUPS, AND SUGARS FROM INDIANA CANES.

These canes were cut, the leaves and tops left undisturbed, the cut surface covered with melted wax, and the whole wrapped carefully in paper and sent by express to the laboratory here for analysis.

Nos. 1 and 2 were cut in the afternoon of October 1 and analyzed October 4, having been three days on the road.

No. 1 was a sample of eight selected canes. No. 2 was a sample of sixteen canes taken seriatim from an average row, and represents the cane as a whole. It seems to have deteriorated very little in transit, and the analyses of the semi-sirup go to show that the average of the whole patch was about a mean of the results of Nos. 1 and 2. No. 3 was cut at 4 p. m. October 1, and analyzed October 6, at 9 a. m., an interval of four days and seventeen hours. The results of this analysis show that the cane had greatly deteriorated.

From this it appears that canes even carefully prepared and protected will not keep in good condition longer than three days in warm autumn weather.

TABLE OF RESULTS.

Indiana canes and sirups.	Sucrose.	Other sugars.
	Per cent.	*Per cent.*
No. 1. Sample of eight selected canes	13. 25	2. 30
No. 2. Sample of sixteen average canes	10 73	3. 71
No. 3. Cane cut October 1	8. 54	5. 99
No. 4. Semi-sirup	36. 76	9. 90
No. 5. Semi-sirup	37. 27	10. 02

SEMI-SIRUPS.

Nos. 4 and 5 of preceding table were taken from semi-sirups made October 1. The sirup was placed in glass-stoppered bottles, sealed with wax, and sent by express to Washington. The analyses were made October 8.

REMARKS—SEMI-SIRUP.

The semi-sirup from the Indiana cane acquired a somewhat darker color by remaining three weeks in barrels than it had at first. It did not, however, suffer any deterioration in its sugar content, and made as much sugar doubtless as it would have done if boiled directly to grain from the concentrating pans.*

This fact is one which may prove of some importance to manufacturers whose strike-pans are inadequate to the capacity of the rest of the works.

My experience confirms that of Professors Weber and Scovell, who last year stored semi-sirup at their works at Champaign, Ill., with success. In such cases, however, it is necessary to be constantly on the alert to guard against every appearance of fermentation. A fermentation once started in a quantity of semi sirup would act like a contagious disease and soon affect every fermentable liquid within its reach. Only necessity, therefore, should lead to the storage of semi-sirup. It should be reduced to melada as soon as possible.

SUGAR.

The sugar made from the Indiana cane was of a light yellow color, slightly tinged with green. Washed with a little cold water in the centrifugal it gave a product almost white, and of a fine flavor. The crystals were large, hard, and bright, and such as would be most highly prized by refiners.

The washed sugar, however, would need no refining. It is already in excellent condition for the table or kitchen.

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*About one quart of lime bisulphite was added to each barrel of semi-sirup.

Subjected to analysis, the Indiana sugar gave the following results:

	Sucrose.	Other sugars.
	Per cent.	*Per cent.*
Washed sugar	97. 27	0. 60
Unwashed sugar	89. 24	4. 55

A sample of the washed sugar sent to M. Dupont, secretary of the French Association of Sugar Chemists, was analyzed by him with the following results: *

	Per cent.
Sucrose	99. 50
Ash	0. 18
Reducing sugar	Trace.
Water and undetermined	0. 32
	100. 00

THE RIO GRANDE, N. J., SUGAR FACTORY.

The sorghum-sugar factory at Rio Grande, near Cape May, N. J., has been in operation three years. The company has a plantation of about 3,000 acres. The soil is a sandy loam.

This company receives from the State of New Jersey a subvention amounting to $1 per ton for the cane and 1 cent per pound for the sugar.

The cane is planted in hills so that it can be cultivated both ways. Each hill is about 10 inches square, and the seeds are planted over this surface and not all in one place.

More seed is planted than necessary for a full stand. After the plants are well up the weak and slender ones are removed, leaving about six healthy stalks to each hill.

The varieties of cane preferred by the company are early Amber and early Orange, equal areas being planted with them. Other varieties are grown for experimental purposes, but not in large quantities.

The canes are brought to the mill on a tramway. The superintendent told me that the cost of transportation was very much diminished by it.

Arriving at the mill the canes are lifted from the trams by machinery. Double milling is employed. The bagasse from the first mill is sprinkled with water before passing through the supplemental mill.

The method of manufacture employed at Rio Grande is a modification of the sulphur process. It is further set forth in the following specification:

To all whom it may concern:

Be it known that I, Henry A. Hughes, of Camden, Camden County, New Jersey, have invented a new and useful improvement in processes of defecating and clarifying saccharine liquors, of which the following is a specification.

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* Bulletin de l'Association des Chemistes de sucrerie et de distillerie, Décembre, 1883, page 366.

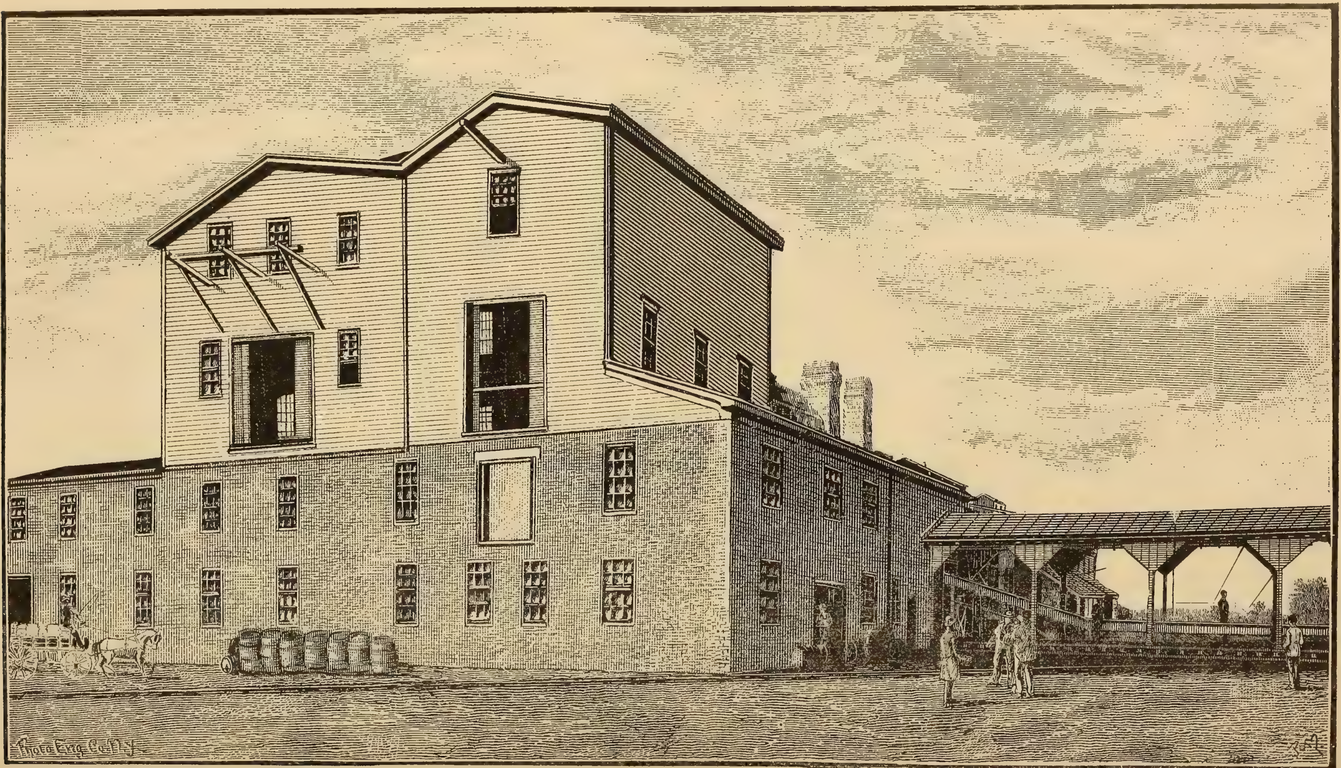
Photo Eng Co N.Y.

FIG. 5.—SORGHUM SUGAR FACTORY, RIO GRANDE, N. J.

The object of the invention is to separate from the saccharine liquors all or the greater portion of the matters therein contained, except sugar and water, this process being commonly known in the art as "defecation" and "clarification." At the present time four general methods may be recognized for accomplishing this result, these methods depending respectively upon the application of heat, upon the use of chemicals, upon filtration, and upon galvanic or electrical action. My invention belongs mainly to the second class, inasmuch as the processes hereinafter described depend chiefly upon the employment of certain chemical agents.

The invention consists in a mixture of sulphurous-acid gas and cream of lime for treating the saccharine liquor. Said mixture I believe to be both chemical and mechanical, inasmuch as there is contained considerable free sulphurous-acid gas in the compound when in best condition for use; also, in the process of treating the saccharine liquor with said mixture in the manner set forth; also in the process of treating the saccharine liquor subsequent to the same being acted upon by the aforesaid mixture with an aqueous solution of acid; also in the process of treating the saccharine liquor with the aforesaid mixture and the dilute acid solution and filtering while cold; also in the process of treating the saccharine liquor with the aforesaid mixture and the dilute acid solution, then heating, and finally filtering; also in the process of delaying fermentation in the saccharine liquors by treatment with the aforesaid mixture and the dilute acid solution; and also in the process of removing the sulphurous taste in sugar, defecated by the aforesaid or any other sulphur processes, by injection of live steam.

The best means which I now know for practically operating the inventions hereinafter claimed and described, is as follows: The juice after being expressed from the cane by any well-known means, is collected in a tank of suitable size, holding, generally, about 1,000 gallons. To it is added a mixture, which is prepared in the following manner: Fresh quicklime is slacked with water, so that the resulting mixture has the consistence of a thick cream, which is conducted into a vat or reservoir. In this vat is arranged a shaft provided with radial arms, which carry beaters or paddles, and means are provided for rotating said shaft in the vat. Said vat, by means of a flue or passage entering at its upper portion, communicates with a furnace suitably constructed for burning sulphur, so that by means of said connecting passage the sulphurous-acid gas, resulting from the combustion of the sulphur, is led into the upper portion of the vat and above the cream of lime therein. Suitable means are provided for drawing in said fumes, so that a constant current of sulphurous-acid gas is caused to enter the vat. The shaft and beaters being set in rotation, the liquid contents of the vat are violently agitated, and at the same time the sulphurous-acid gas is beaten into and caused to mingle with the same. The process of mixing the gas and cream of lime is continued until the liquid assumes a clear yellow color and gives, when tested with litmus test-paper, a strongly acid reaction. This acid reaction is essential. The liquid also has a clearly perceptible sulphurous smell. The exact length of time for beating and passage of sulphurous-acid gas in the cream of lime cannot definitely be stated; but for all practical purposes it will be sufficient if the liquor presents the characteristics before stated, when it will be ready for use. It is preferable to make the cream of lime of as thick a consistence as possible, while at the same time not so thick as will prevent the working of the beaters. It will be noticed also, that shortly before the cream of lime becomes impregnated with sulphurous-acid gas, so as to reach the condition before described, its temperature becomes considerably elevated to a degree almost enough to scald the naked hand. After the liquid reaches the before-stated condition, further continuation of the process depends upon the state of the cane-juice to be treated. Thus, if the juice is pressed from frost-bitten, soured, or otherwise damaged cane, so that the juice is more than normally sour, it is advisable to continue the impregnation of the cream of lime for from ten to twenty minutes longer, or generally to bring the liquor to a higher degree of concentration, strength, and acidity. The apparatus before set forth for combining the lime and sulphurous-acid gas I do not claim in this application, inasmuch as the same forms the subject of a separate application filed herewith, to which reference is made for details of the mechanism.

I desire to call especial attention to the fact that the above-named substance, to which I have given the name of "sulphureted cream of lime," is in fact not bisulphite of lime, but is probably a combination of bisulphite, hyposulphite, and pentasulphite of lime, or, in fact, all possible sulphites, inasmuch as it is made by the saturation of cream of lime with sulphurous acid up to and beyond the satisfaction of all chemical affinities. It must, when first made, and in best condition for use, show the yellow color before mentioned, and give off fumes of sulphurous acid gas.

I am aware that bisulphite of lime has been used for defecating sugar juice, and that various processes of defecation are in existence depending upon the use of that material. I desire to disclaim any and all processes of sugar defecation which depend upon the addition of bisulphite of lime only to the liquor to be tested.

I am also aware that there are known processes of sugar defecation involving the use separately of quicklime and sulphurous acid in solution, these materials not being combined, but being successively added to the liquor. Such use or separate application of sulphurous acid and quicklime form no part of my invention, and is hereby disclaimed.

To the cane juice collected in the tank I add such a proportion of the sulphurous acid and cream of lime, combined as before stated, as will render the contents of the tank slightly turbid. No definite proportion can be stated, nor is it necessary to do so for practical purposes. The test of turbidity is sufficient, and itself determines the amount of the mixture to be added. It is important to note, however, that the condition of the juice hastens or delays the turbid appearance. Thus, if the juice is normally neutral a very small proportion of the mixture will render it turbid. On the other hand, if the juice is acid the turbid condition will be delayed in some proportion to the acidity. The effect of adding the mixture to the juice is to cause a precipitation of the coloring matters and other impurities, excepting the mucilage or gum. This effect is best produced when the mixture is used immediately after production, as it should be. The mixture deteriorates if allowed to stand in air. If it is necessary to keep the mixture for any length of time it should be hermetically sealed up in air-tight vessels with a solution of sulphurous acid in water over the top of the liquid, on which it will float. The precipitation takes place immediately, and the juice may be at once pumped or otherwise removed from the tank to the defecators, where it is heated and the scum is removed in the usual way. The principal defecation, of course, takes place in the tank, as already described, and a still further defecation occurs through the action of heat in the defecating vessels. From the defecators the juice goes to the evaporators, thence to the vacuum pans, then to the coolers or mixers, and finally to the centrifugal machine, the course of the juice after leaving the defecators being the same as it ordinarily follows when known processes of defecation are employed. In order to remove the sulphurous flavor of the sirup, which comes from the centrifugal machine, I find it advantageous to collect said sirup in a suitable tank provided with perforated steam pipes, through which live steam is injected into the sirup. This injection of steam is continued until the sulphur taste is no longer apparent. The sugar resulting from this process contains considerable of the natural gum, and, although quite light in color, has a small grain, and is not easy to purge in the centrifugal machine. It is, however, an excellent marketable product, and gives a high polariscopic test.

Returning, now, to the defecated juice in the tank, I find that a somewhat better sugar may be produced by continuing the process in the following way: I prepare a weak solution of sulphuric acid—preferably about one volume of acid to four volumes of water. I do not limit myself to sulphuric acid, as I have found that other acids, notably hydrochloric and acetic acids, when in a weak solution, will accomplish substantially the same result. It is desirable, however, that the strength of the acid solution should not be greater than is indicated by the proportions of sulphuric acid and water before stated.

This acid solution is to be added to the defecated juice in the tank preferably in the proportion of five hundred cubic centimeters of acid solution to one thousand gallons of juice. I have found this proportion to work well with sorghum juice It can be exceeded, probably, to a considerable extent without danger, though with no perceptible advantage in results. Care, however, is to be taken not to add too much of the acid solution, as the consequence might be to invert the sugar. The effect of the acid solution upon the defecated juice is to throw down the gum, or mucilage, some of which is actually precipitated immediately, and all eventually, if the juice is allowed to stand long enough for the light flocculent material to gravitate to the bottom. The success of the operation is at once manifested by the rising of sulphurous fumes from the juice, the odor of which is plainly perceptible.

As the deposition of the light mucilaginous material requires some delay, it is better, in order to save time, to separate it out by means of a filter press of any suitable construction, from which the filter juice emerges clear. It will be seen that this process gives a cold defecation, and thus accomplishes a result of great value and importance. A slightly better grade of sugar can be made, however, by conducting the juice to the defecating vessels and there warming it nearly to the boiling point before passing it through the filter press; but this warming of the juice is not essential to the production of excellent sugar by the aid of my process, as described.

In the cold process, as I have described it, the juice passes from the filter presses directly to the vacuum pan, thus entirely dispensing with defecators and clarifiers. Care, however, must be taken that the filter press is properly worked, and that none of the scum is allowed to mingle with the juice. In the warm process the juice passes, as already stated, from the defecators to the filter press, and thence to the clarifiers. So far as the relative advantages of the two processes are concerned, the cold process requires greater care in operation, and produces almost if not equally as good a grade of sugar, and does away with defecating and clarifying vessels and the skilled labor and expenses attendant upon their use. The warm process, on the other hand, requires less care in its general operation, but involves the use of defecators and clarifiers to compensate for such lack of care, and produces a grade of sugar which a very experienced eye only would class as of better grade than that made by the cold process. When treated by either process, the course of the juice after leaving the vacuum pan is the same as already set forth. The resulting sugar is free from gum, or very nearly so, and is generally of considerably better quality, both in grain, color, and test than that made without the use of the weak acid solution.

An important advantage of my invention is as follows: It is well known that cane-juice, after being expressed, will ferment in a very short time, and inversion of the sugar is the result, so that it is available only for the manufacture of alcohol or poor molasses. After the juice is treated with the sulphureted lime mixture and the acid solution, as I have before described, it will remain unchanged, and no fermentation will take place as long as the sulphurous acid fumes continue to be emitted from it, whether it is exposed to the air or not. I have kept such juice exposed to the air in a warm room for three month thout detecting perceptible deterioration in it.

The foregoing process I have described as I have practically applied it to the juice of the sorghum plant, the crop being raised in the State of New Jersey. I have found it to be applicable equally well to the ordinary sugar-cane and to the manufacture of molasses sugars from molasses imported from the West India Islands. It is equally applicable to the improvement of any raw sugars, these being dissolved in water prior to the addition of the lime mixture and acid solution.

It will be observed from the foregoing that in the processes described the liquor remains acid—that is, gives an acid reaction to the test paper throughout—and in this respect the said processes differ materially from ordinary lime or lime and sulphur processes wherein the liquor is kept neutral. This acidity I remove, either wholly or in great measure, by the boiling of the liquor in the evaporators and vacuum-pans.

I claim as my invention—

1. The defecating compound or mixture for saccharine liquors herein particularly set forth, consisting of cream of lime and sulphurous acid mingled and combined till the said cream of lime is completely saturated with sulphurous acid, substantially as described.

2. The process herein set forth of defecating saccharine liquors, consisting in adding to the juice the sulphureted cream of lime compound herein set forth prior to heating the same in defecating vessels, substantially as described.

3. The process of defecating saccharine liquors, consisting in first adding to the juice the sulphureted cream of lime compound herein set forth, and, second, a dilute aqueous solution of acid, substantially as described.

4. The process of defecating and clarifying saccharine liquors as herein set forth of, first, adding to the juice the sulphureted cream of lime compound herein set forth, and afterwards a dilute aqueous solution of acid, and then filtering the juice while cold, substantially as described.

5. The process of defecating and clarifying saccharine liquors, as herein set forth, consisting in, first, adding the sulphureted cream of lime compound herein set forth to the juice, and second, a dilute aqueous solution of acid, and then heating said juice in defecating vessels, and finally filtering the same, substantially as described.

6. The method of delaying fermentation in saccharine liquors, consisting in adding to said liquors, first, the sulphureted cream of lime compound herein set forth, and, second, a dilute aqueous solution of acid, substantially as described.

7. The process herein set forth of removing the sulphurous taste or odor of sirups defecated by a sulphur process, consisting in injecting live steam in said sirups, substantially as described.

8. The process of defecating and clarifying saccharine liquors, consisting in adding to said liquor an acid solution or solutions, whereby said liquor is rendered acid, and finally removing said acidity, either wholly or in great part by boiling the liquor, substantially as described.

THE PIG PENS.

A point of interest in the Rio Grande factory is the pig pens. The seed of sorghum has generally been neglected, and therefore the successful attempt of the Rio Grande Company to utilize it at home demands most serious attention. There is no part of this company's possessions which excited in me a more lively interest than this plan of utilizing the seed and bagasse and thus returning in a great measure to the land the substances abstracted by the crop.

I found in these pens in October three hundred hogs of different ages, some full grown and fat for the market, others newly born.

These swine had never had any other food than the product of the cane and no other bedding beside the bagasse. They were fat and healthy, and the swineherd assured me that he had never lost animals from any of the contagious diseases so fatal to swine.

From the experience which the company has already had they think that each acre of cane will furnish enough seed to fit one hog for market.

The bagasse from the mill, which is brought out by the cars, which would otherwise return empty, is thrown into the pens. By spring it is converted into an excellent manure which will almost be enough for one acre of ground for each animal.

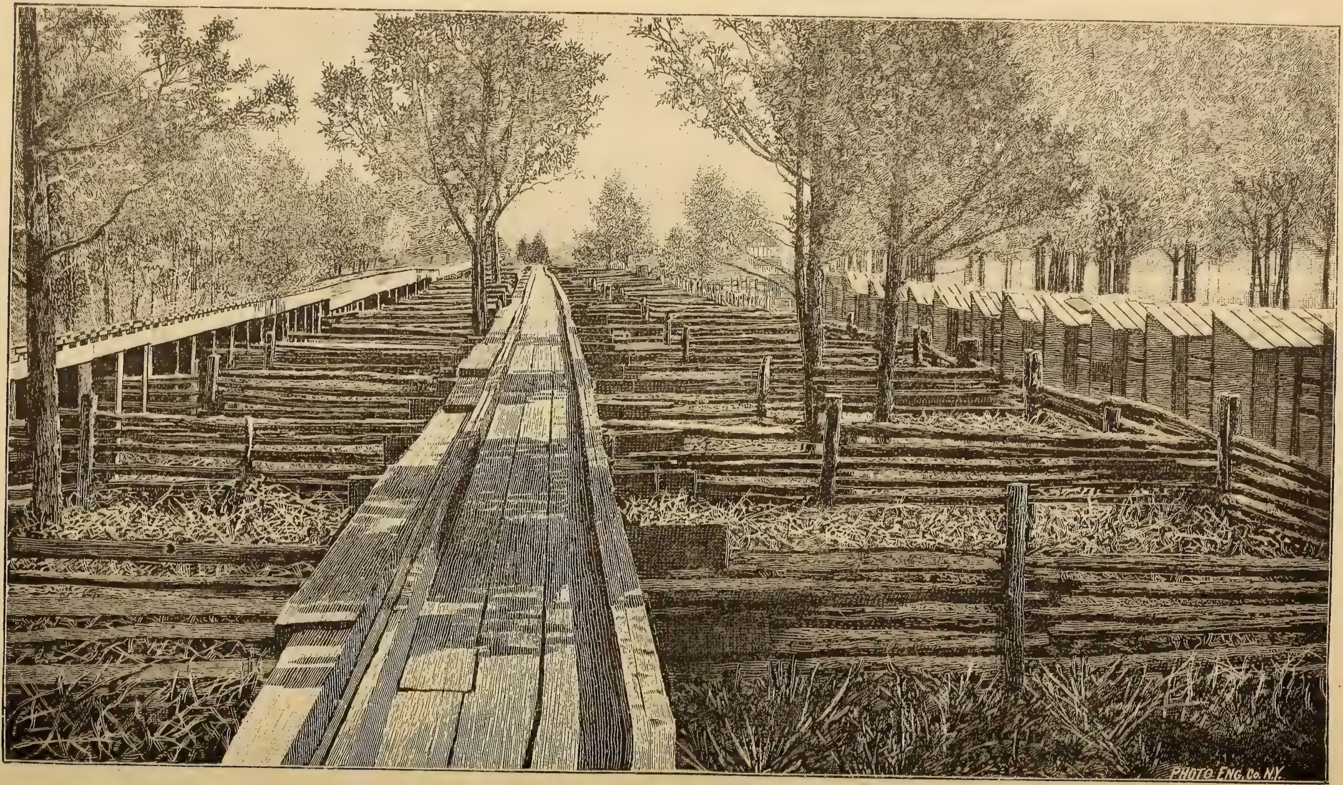
PHOTO-ENG. Co. N.Y.

FIG. 6.—PIG-PENS, RIO GRANDE SUGAR COMPANY.

In order to place sorghum culture on a truly economic basis every by-product must be carefully utilized, and among these the seed is the most valuable.

Before the seed is fed it is boiled until the starch granules split open and thus complete digestion is secured. It would be extremely wasteful to feed the raw seed.

There is no reason to doubt that boiled sorghum seed would prove as palatable and beneficial to other animals as to swine.

SEDIMENTS AND SCUMS.

The sediments and scums are also saved at Rio Grande, and make a most valuable fertilizer.

The sediments contain the excess of lime and the lime sulphate and any phosphoric acid that may have been found in the juice. The scums are rich in nitrogen.

Many tons of this valuable stuff, which ought to be preserved and restored to the soil are thrown away annually throughout the country.

ANALYSES OF SORGHUM PRODUCTS FROM RIO GRANDE SUGAR COMPANY, RIO GRANDE, CAPE MAY COUNTY, NEW JERSEY.

Canes selected from volunteers growing among corn, fertilized with last year's scum.

Number of canes		8
Total weight	kilograms	5.82
Net weight (stripped and topped)	do	4.50
Average weight	do	.56
Weight, bagasse	do	1.44
Juice expressed	per cent	68.00
Specific gravity (22° C.)		1.063
Total solids	per cent	15.36
Ash	do	.55
Solids not sugars	do	2.48
Glucose	do	3.25
Sucrose	do	10.63

Canes fertilized with salt muck.

Number of canes		6
Total weight	kilograms	4.9
Net weight (stripped and topped)	do	3.2
Weight, bagasse	do	1.13
Juice expressed	per cent	69.7
Specific gravity (22° C.)		1.078
Total solids	per cent	17.78
Ash	do	1.14
Solids not sugar	do	3.23
Glucose	do	1.77
Sucrose	do	12.78

Canes from carrier September 22, 1883.

Number of canes		25
Total weight	kilograms	3.53
Weight, bagasse	do	1.40

Bagasse	per cent	39.80
Juice expressed	do	60.2
Specific gravity at 22° C		1.060
Total solids	per cent	15.27
Ash	do	.46
Solids not sugar	do	.96
Glucose	do	4.99
Sucrose	do	9.32

I selected these canes at the factory, prepared them, as already described, for canes to be shipped by express. They were analyzed here on the third day after they were cut.

Further information concerning the Rio Grande factory will be found in the following letter from Mr. Hughes, the superintendent, to whom and the president of the company, Mr. Potts, I am indebted for many courtesies:

RIO GRANDE, N. J., *December* 6, 1883.

SIR: The mill commenced grinding September 10 and stopped November 14. The amount of unstripped cane ground was 6,795.811 tons. We made 282,711 pounds sugar and about 55,000 gallons molasses.

Sucrose by polariscope, average for the season	per cent	9.75
Sp. gr. Baumé, average for the season	degrees	7.57
Against last year's polariscope	per cent	11.11
Sp. gr. Baumé	degrees	7.33

The bulk of the crop was Amber and Orange; the per cent. of juice ranged from 55 per cent. to 40 per cent. on the unstripped canes; over half the sugar being left in the bagasse.

We have two mills; the second one was not properly rigged up.

Being afraid the cane would get over ripe, as it has always done before, we planted later than usual. The season turned out very wet and cold. The Orange did not ripen until October 29, except in those fields where phosphoric acid was put in the hill. A storm in September prostrated the Amber. For these two reasons we had bad cane from September 24 to October 29. During this time no pan failed to granulate, but the yield of sugar was poor. From October 29 until the end of the season, the cane was first rate. The extreme low price of sugar, and the high price of choice New Orleans molasses caused us to make a better sirup than we would ordinarily have done. In this way over 100,000 pounds of sugar was allowed to go into the molasses simply because this year it paid to do it.

Yours, truly,

H. A. HUGHES,
General Manager Rio Grande Sugar Company.

Prof. H. W. WILEY.

Table of data derived from preceding letter.

Acres (about)	1,000
Tons	6,795
Tons per acre	6.795
Pounds sugar made	282,711
Pounds sugar per ton	41.6
Gallons molasses	55,000
Gallons molasses per ton	8.09
Average per cent. of sugar in juice	9.75
Average per cent. of juice expressed	47.00

The total value of sugar produced at 7 cents per pound was	*$19,789.77
Add bounty 1 cent per pound	$2,827.11
Value of molasses, at 42 cents per gallon	$23,100.00
Bounty on cane ($1 per ton)	$6,795.00
	$52,511.88
Value per acre (*circa*)	$50.00

OPERATIONS AT CHAMPAIGN, ILL.

The campaign of 1883 was the second one for this company.

The method of planting and cultivation was a simple one, and with the exception of some special attention given the young plant with the hoe, was the same as is used in raising Indian corn.

The company does not cultivate a large crop of its own, but buys of surrounding farmers.

The soil around Champaign is a black prairie loam.

The season was cold and wet, and the early September frosts greatly injured the crop.

The company made an interesting experiment during the working season in burning the bagasse directly from the second mill.

Special furnaces were constructed for the purpose, with blast and tall chimney to favor rapid combustion. The bagasse in passing to the supplemental mill is saturated with steam and hot water. It reaches the furnaces, therefore, still wet, probably containing nearly half its weight of water. There are grave difficulties connected with burning such a fuel which even the most ingenious construction of a furnace will hardly overcome.

The saving of fuel by burning the bagasse is estimated by the superintendent at 25 per cent.

Experiments in other parts of the country, notably in Kansas, have shown that well sun-dried bagasse is more than sufficient fuel for evaporation. It is therefore seen that fully 75 per cent. of the value of the bagasse is lost in burning it wet.

It is yet an open question whether it is sounder economy to burn the bagasse, as at Champaign, or to return it to the soil, as at Rio Grande.

On principle I would be in favor of the latter proceeding. I believe a soil needs the same careful feeding and the same careful attention that a wise farmer gives to his horses and cattle. Penuriousness is always reprehensible, and in farming especially when it is exercised toward the soil. The earth is patient. It will allow itself to be robbed for many years without complaint. Sooner or later, however, it will refuse to do more, no matter how much it is urged.

The wisdom of burning bagasse depends on a great many local considerations. In localities where fuel is scarce and the land fertile it will evidently be more advantageous to burn the bagasse than where coal is abundant and the soil poor.

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* These figures are my own estimates, and have not been revised by the officers of the company

Again it must be remembered that to burn the bagasse from the mill successfully, costly furnaces and apparatus have to be constructed. This will add a considerable item to the bill expenses.

Even with such appliances the amount of other fuel required is not greatly less than in ordinary furnaces.

I am not quite prepared to believe that sorghum will furnish the fuel to boil its juices unless the bagasse is first carefully dried.

I therefore await with interest the results of several years experience with bagasse burners. Like all other problems in sorghum culture and manufacture, it would be decidedly unwise to determine them from a single season's work.

METHOD OF MANUFACTURE AT CHAMPAIGN, ILL.

The Champaign Company uses the Weber and Scovell patent. The essential features of this method are as follows:

1. The addition of lime to the expressed juice until the free acids are completely neutralized.

2. The further defecation of the juice by heat and its concentration, after removal of scums and sediments, to a semi-sirup of 20°–25° B.

3. The filtration of this sirup through bone-black to remove impurities and whiten the sugar.

The operations in the vacuum pan, the crystallizing room, and at the centrifugals are the same as at other factories.

This process makes a beautiful and pure sugar, which is fit for the table without any further refining. In fact, the refining takes place during the process of manufacture.

The radical difference between this and the Hughes process is at once apparent, and proves that there is more than one way to make sorghum sugar.

Prof. H. A. Weber, the manager of the Champaign works kindly furnished me with the following information in answer to questions the nature of which appears from his replies:

CHAMPAIGN, ILL., *December* 15, 1883.

DEAR SIR: In compliance with your letter of November 15, I have the honor to submit the following answers to the questions asked:

1. The whole amount of cane worked this season was 4,660 tons, about half of which was stripped; the rest was crushed with the leaves.

2. About 60 per cent. of the juice was expressed.

Double milling was employed.

3. Number of pounds of sugar made, 160,000.

4. Number of gallons of molasses made, 35,000.

5. The average composition of the juice worked this year, was as follows: Specific gravity 8° B. = 1.0591; cane sugar, 7.78 per cent.; grape sugar, 4.76 per cent.

It may be well to state that the inferiority of the juice was due to a heavy frost on September 8 and 9, which killed the leaves of the greater part of our cane. This had the same effect upon the cane that stripping and allowing to stand would have had. The quality of the cane deteriorated from that date until it was worked up.

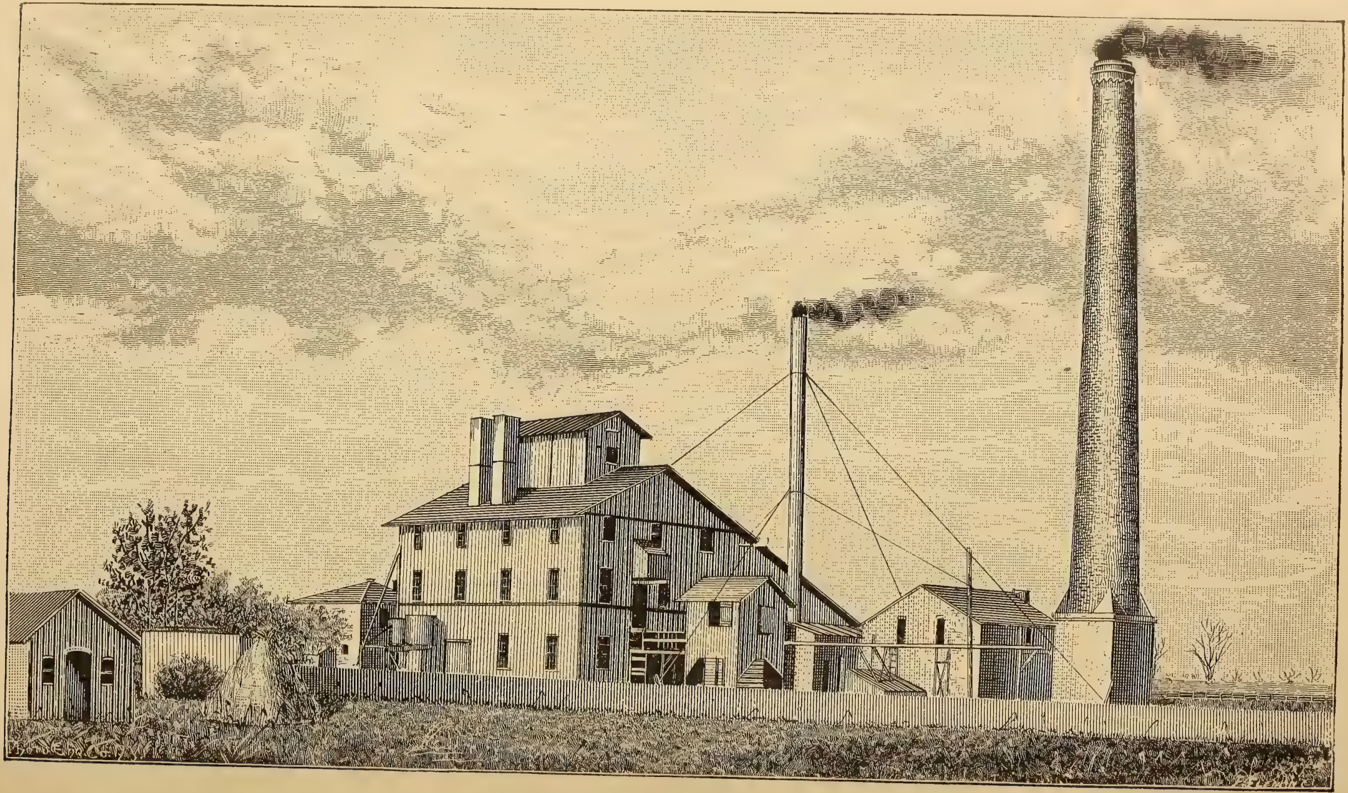

FIG. 7.—CHAMPAIGN, ILL., SORGHUM SUGAR FACTORY.

6. The best varieties of cane for our climate are Early Amber and Early Orange.
7. The average length of working season with us is about sixty days.
8. If the last two seasons were average seasons for our section of the country, I think there is no doubt that we are entirely too far north for the successful manufacture of sugar. But compared with the past these two seasons must be regarded as quite abnormal, and if the climatic conditions previous to 1882 should obtain, I think it would be safe, for the West at least, to place the northern limit of successful sugar manufacturing as far north as the latitude of Chicago.

Very respectfully,

H. A. WEBER.

Prof. H. W. WILEY,
Washington, D. C.

Professor Weber has also made some interesting experiments in removing the heads from the sorghum stalks as soon as they appear. In all cases this procedure produced an increase in the sugars in the cane—sensibly equal to the quantity of starch which would have been formed had the heads ripened.

This experiment, both as it relates to increase of sugar and to the securing of the crop from the ravages of storms, is one of the greatest importance to the future of this industry.

EXPERIMENTS IN KANSAS.

HUTCHINSON, KANS.

The sugar works at Hutchinson, under the supervision of Prof. M. Swenson, made, during the season of 1883, 131,000 pounds of sugar and 30,000 gallons of molasses.

The soil in this part of Kansas, near the Arkansas River, is a sandy loam, with a preponderance of sand. This excess of sand is so marked that in some fields it is quite impracticable to plant sorghum until after the season of spring winds has passed. The winds blow the sand with such force that it acts like a sand-blast on the young plants, cutting them off even with the ground.

The summers and falls are generally dry. The soil, however, is so loose that the roots of the plant grow deep. In one instance I was informed of a tap root having been traced to the depth of 10 feet.

By reason of this depth of root the plant does not suffer greatly from the drought.

The dry weather of the fall season is peculiarly favorable to manufacture, and to drying the bagasse for fuel.

I append a table of analyses of sorghum products made under the direction of Professor Swenson.

This table shows that ripe cane in Kansas may be expected to contain more than 10 per cent. of sucrose.

Copy of record of analyses of sorghum made at Hutchinson, Kans., during season of 1883, *by Prof. Magnus Swenson, chemist of Kansas Sugar Refining Company.*

AMBER.

Date.	Specific gravity.	Deg. Brix.	Per cent. glucose.	Per cent. sncrose.	Per cent. other solids.	State of seed.
Aug. 9	1.0460	11.4	1.6	....	....	
9	1.0420	10.5	2.4	7.2	.9	
10	1.0493	12.2	2.9	6.4	2.9	
10	1.0470	11.6	3.7	....	....	
10	....	13.0	....	....	....	
11	1.0475	11.7	2.9	7.2	1.6	
11	1.0464	15.6	2.7	7.3	5.6	Milk.
12	1.0476	11.7	2.9	6.8	2.0	
12	1.0570	14.0	2.8	9.0	2.2	
13	1.0567	14.0	2.8	8.0	3.2	Milk.
14	1.0447	10.8	2.6	6.9	1.3	
14	1.0564	14.0	....	......	......	
14	1.0674	16.3	2.1	11.4	2.8	
14	1.0517	12.6	3.3	....	....	Flower.
14	1.0578	14.2	....	....	....	Milk.
14	1.0570	14.0	2.3	....	....	Hard.
15	1.0570	14.0	2.3	9.0	2.7	Soft.
15	1.0622	15.2	1.9	10.9	2.4	Hard.
16	1.0000	13.0	2.3	....	....	
16	1.0000	14.5	3.3	....	....	Soft.
16	....	15.0	....	....	....	Soft, hard.
16	....	12.2	....	....	....	Flower.
17	1.0544	13.4	2.5	8.3	2.6	Soft.
17	1.0560	13.7	2.5	8.4	2.8	Hard.
17	1.0590	14.4	....	....	....	Hard.
17	1.0637	15.5	....	....	....	Medium.
17	1.0625	15.3	....	....	....	Soft.
17	1.0595	14.6	....	....	....	Medium.
17	1.0665	16.2	....	....	....	Hard.
17	1.0640	15.6	....	....	....	Medium.
17	1.0580	14.2	....	....	....	Hard.
17	1.0520	12.8	....	....	....	Medium.
17	1.0590	14.4	....	....	....	Hard.
17	1.0620	14.7	....	....	....	Medium.
17	1.0640	15.6	....	....	....	Hard.
17	1.0594	14.5	....	....	....	Medium.
19 Heavy rain						
20	1.0440	10.8	....	....	....	Hard.
20	1.0560	13.7	....	....	....	Soft.
20	1.0577	14.2	....	....	....	Hard.
20	1.0594	14.6	....	....	....	Hard.
20	1.0573	14.1	....	....	....	Milk.
20	1.0614 1.0617	15.0	....	....	....	Hard. Soft.
20	1.0610	14.9	....	....	....	Hard.
20	1.0617	15.1	....	....	....	Milk.
20	1.0463	11.5	....	....	....	Sod flower.
21	1.0505	12.5	1.7	8.1	2.7	Hard.
21	1.0592	14.5	2.5	9.8	2.2	Hard.
21	1.0505	12.5	3.1	6.3	3.1	Flower.
21	1.0627	15.4	....	....	....	Hard.
23	1.0703	17.1	2.8	13.5	.8	Select.
23	1.0620	15.2	3.8	9.7	1.7	Ripe.
25	....	13.5	3.3	8.5	1.7	Average of load.
25	....	14.0	3.4	9.0	1.6	Average of load.
27	1.0592	14.6	3.4	9.3	1.9	
28	1.0505	12.5	2.9	8.0	1.6	
31	1.0550	13.5	3.1	8.6	1.8	Hard.
31	1.0666	16.3	3.1	11.3	1.9	Hard.
31	1.0625	15.3	3.2	11.1	1.0	Hard.
Sept. 1	1.0780	18.8	3.0	14.1	1.7	Select.
1	1.0670	16.3	....	....	....	Hard.
1	....	15.6	....	....	....	
1	....	17.3	3.2	....	....	
5	1.0829	20.0	4.2	....	....	Three days in yard.
8	1.0700	17.0	4.0	10.2	2.8	Defecated juice.
12	1.0660	16.0	2.9	11.5	1.6	Defecated juice.
14	1.055	13.5	2.0	....	....	
18	....	15.5	2.8	11.8	1.0	Defecated juice.
18	....	15.0	2.6	11.4	1.0	Defecated juice.

Copy of record of analyses of sorghum made at Hutchinson, Kans., &c.—Continued.

MIXED FROM MILL.

Date.	Specific gravity.	Deg. brix.	Per cent. glucose.	Per cent. sucrose.	Per cent. other solids.	State of seed.
Oct. 1	...	16.5	2.6	11.8	2.1	
2	...	16.5	2.9	11.9	1.7	
3	...	16.0	2.8	11.9	1.3	
5	...	17.5	4.0	...	...	
7	...	15.0	5.4	8.5	1.1	
8	...	16.5	4.5	10.5	1.5	
10	...	15.0	3.0	11.7	...	
13	1.0548	13.5	3.5	9.3	0.7	
13	...	14.5	2.9	10.7	0.9	
15	...	16.0	2.7	12.0	1.3	
17	...	14.5	2.3	10.4	1.8	
19	...	16.0	3.7	12.6	...	
19	...	16.5	3.2	11.7	1.6	

ORANGE CANE.

Date.	Specific gravity.	Deg. Brix.	Per cent. glucose.	Per cent. sucrose.	Per cent. other solids.	State of seed.
Aug. 12	1.0324	8.1	3.6	...	...	
13	1.0360	9.0	3.5	2.2	3.2	
15	1.0416	10.3	4.0	4.5	1.8	
21	1.0387	12.0	...	...	...	
18	...	11.6	...	...	...	
18	...	11.8	...	...	...	
18	...	9.4	...	...	...	
21	1.0487	12.0	...	...	...	
21	1.0434	10.7	...	...	...	
21	1.0447	11.0	...	...	...	
21	1.0270	7.0	...	...	...	
21	1.0480	11.9	...	...	...	
22	1.0545	13.4	4.7	6.7	2.0	Milk.
22	1.0509	12.6	3.8	7.2	1.6	Hard.
22	1.0665	16.3	4.2	10.2	1.9	Hard.
23	1.0503	12.4	4.3	6.1	2.0	Heading.
23	1.0620	15.2	3.7	9.7	1.8	Hard
23	1.0696	16.9	4.7	11.1	1.1	Milk.
23	1.0430	10.7	3.7	6.0	1.0	
23	1.0489	12.0	4.3	6.2	1.5	
23	1.0430	10.7	3.4	6.4	0.9	
27	...	14.7	3.8	9.0	1.9	
27	1.0444	11.0	3.8	5.4	1.8	
27	1.0500	12.4	...	...	...	
27	1.0454	11.2	...	...	...	
28	1.0577	14.2	3.8	8.9	1.5	
29	1.0540	14.4	...	...	...	
31	1.0687	16.7	2.6	13.5	...	Ripe.
Sept. 1	1.0686	16.7	4.6	10.3	1.9	Soft.
1	1.0500	12.4	...	...	...	
1	...	17.1	4.0	...	...	
14	1.0540	13.3	...	...	...	
14	1.0650	16.0	2.0	...	...	Soft.
14	...	13.5	2.5	9.1	1.9	
19	...	16.5	4.2	11.4	0.9	Milk.
19	...	17.0	1.9	13.2	1.8	Soft dough.
19	...	15.5	2.1	11.2	2.2	Av. of load.
19	...	15.0	2.3	11.2	1.5	
20	...	16.5	2.4	12.0	2.1	

LINK'S HYBRID.

Date.	Specific gravity.	Deg. brix.	Per cent. glucose.	Per cent. sucrose.	Per cent. other solids.	State of seed.
Aug. 18	1.0305	8.1	...	...	...	
21	1.0480	11.9	...	...	...	
23	1.0471	11.7	2.1	8	1.6	
27	1.0567	13.9	...	...	...	
Sept. 1	1.0550	13.6	4.1	8.1	1.4	
12	...	14.5	1.5	9.8	3.2	
20	1.0830	19.0	0.8	15.4	2.8	Hard.

Copy of record of analyses of sorghum made at Hutchinson, Kans., &c.—Continued.

HONDURAS.

Date.	Specific gravity.	Deg. Brix.	Per cent. glucose.	Per cent. sucrose.	Per cent. other sugars.	State of seed.
Sept. 1	1.0677	16.4	3.6	10.8	2.0	
Oct. 2	1.0560	14.0	3.2	9.5	1.3	

STERLING, KANS.

This factory was under the supervision of Professor Scovell, and was operated exactly as the factory at Champaign, Ill. The soil and climate are the same as at Hutchinson.

The amount of sugar made was 136,000 pounds; of molasses, 35,000 gallons.

Unfortunately I cannot get any exact data in respect of the yield of cane per acre and of sugar per ton in Kansas, because much of the cane was worked without weighing.

The most reliable estimates place the yield of Amber cane at 9.5 tons and that of Orange at 12 tons per acre.

I am disposed, to believe, however, from experience, that estimated yields are generally too high. The following communication from the special agent of this Department for Kansas (who also furnished the statistical tables for the State) will be found of interest:

AVERAGE YIELD OF CANE.

It is difficult to ascertain the exact average yield because a large number of producers do not weigh their product The average of crops weighed are for topped cane with blades on, Amber cane, per acre, 9.50 tons; Orange cane, 12 tons.

The estimates of growers who have not weighed their cane are usually 15 to 25 per cent. above these figures.

A remarkable case illustrating the value of irrigation was that of J. E. Crane of Kinsley, who produced 42 acres of Amber cane. The entire 42 acres received exactly the same treatment except that 30 acres were irrigated with water drawn in a canal from the Arkansas River, while the remaining 12 acres were not irrigated. The cane was cut, topped, and sold to Hon. John Bennyworth, and by him made into sirup. The yield was as follows: not irrigated, 12 acres, 10 tons per acre, 120 tons; irrigated, 30 acres, 17 tons per acre, 510 tons.

Mr. Crane states that the expense of irrigating was:

Water rent per acre, $1; labor of applying water per acre, 50 cents. Total per acre, $1.50. Only one application was made. This irrigated cane is reported to have yielded an unusually rich juice.

If further investigation and furture cultivation shall confirm the experience of Mr. Crane, a most important development awaits such portion of the western third of Kansas as can be cheaply irrigated, and the sugar industry may be largely developed in a section not well adapted to the production of standard cereals.

Respectfully,

E. B. COWGILL,

Agent for Collection of Information of the Sorghum Industry of Kansas.

Hon. GEO. B. LORING,

Commissioner of Agriculture.

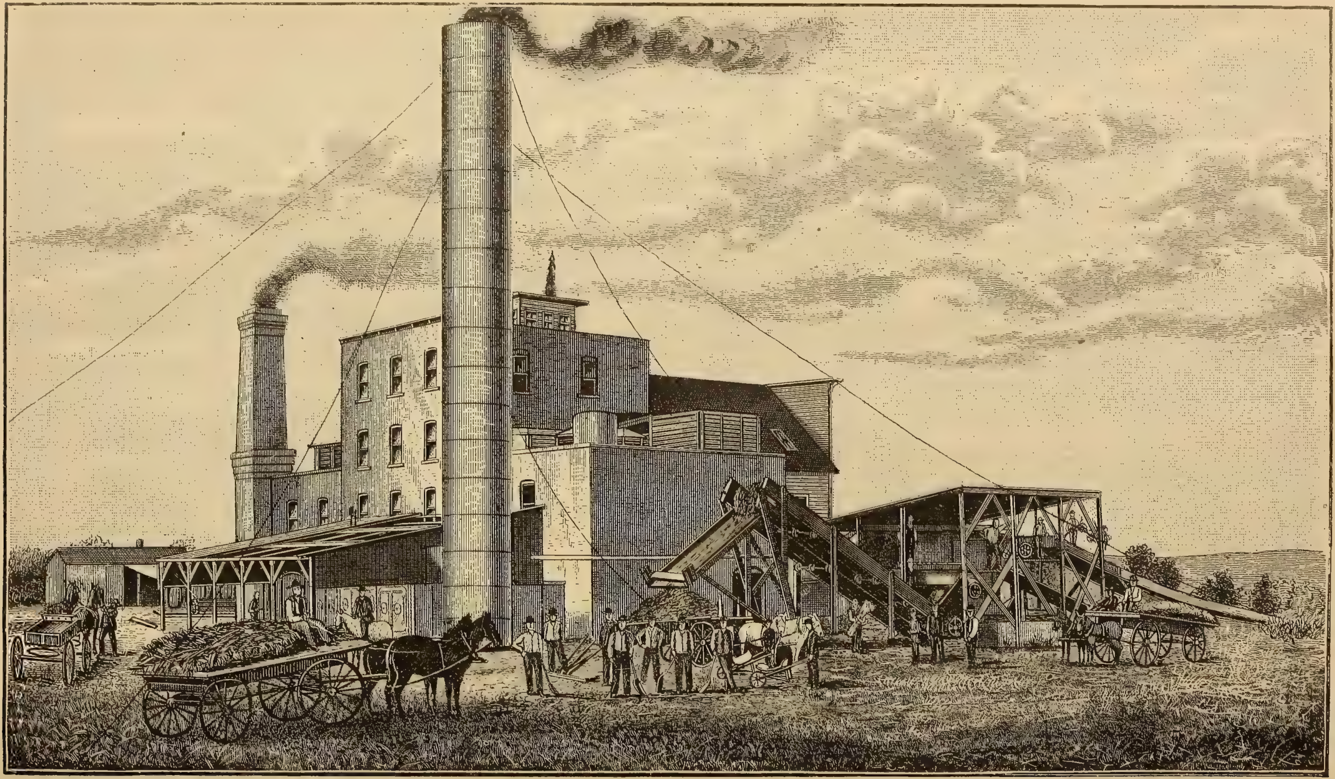

FIG. 8.—HUTCHINSON, KANS., SORGHUM SUGAR FACTORY.

Analyses of cane juice.

Copy of report of Prof. M. A. Scovell, chemist of Kansas Sugar Company, Sterling, Kans.

Date.	Variety of cane.	State of development.	Specific gravity.	Glucose.	Sucrose.	Solids not sugar.	Remarks.
				Per cent.	*Per cent.*	*Per cent.*	
1883. Aug. 6	Early Amber	Seeds in milk	1.0566	3.70	7.42	2.78	
7	....do	Seeds forming at top of panicle, glumes just beginning to turn.	1.0583	3.55	8.56	2.11	
7	....do	Panicle in blossom	1.0502	5.11	4.81	2.48	
9	....do	Seeds in milk, glumes beginning to turn.	1.0570	3.93	7.21	2.86	
9	....do	Just heading	1.0286	3.97	1.56	1.67	
8	....do	Seeds just beginning to be milky.	1.0587	4.72	7.09	2.59	
10	....do	Seeds in milk	1.0536	3.27	7.49	2.34	Same as August 8, but two days older.
11	....do	..... do	1.0536	3.34	7.43	2.32	Short stalks selected on account of appearing riper. Greater milk at field longer but not so ripe.
11	....do	......do	1.0609	4.17	7.97	2.75	Average at field taller than preceding, but not so ripe.
13	....do	......do	1.0626	3.76	8.34	3.20	Same as preceding, two days later.
14	....do	Some seeds just forming.	1.0447	5.11	3.60	4.28	Cut 13th, analyzed 14th; stalks dry and much wilted.
14	....do	Barely out of blossom,	1.0643	7.98	4.55	3.17	Cut 13th, analyzed 14th; cane green and much wilted.
13	....do	Cane in blossom	1.0570	4.00	7.49	2.59	
14	....do		1.0604	4.09	7.94	2.77	Cut 13th, analyzed 14th.
13	....do	Just forming seed	1.0485	3.98	6.27	1.75	Supposed volunteer cane.
14	....do		1.0510	5.33	7.92	2.75	
14	....do		1.0604	4.21	8.35	2.24	
18	....do	Seeds in milky dough.	1.0617	3.76	8.58	2.76	Same field as Aug. 11.
18	....do	Seeds in softening dough.	1.0570	3.33	7.92	2.75	Same as preceding.
17	....do	Cane very green; not blossomed.	1.3970	3.93	4.18	5.55	
17	....do	Seed just forming	....	3.72	6.68	3.30	
17	....do	Seed almost in hardening dough; glumes quite dark.	1.0643	3.64	9.55	2.51	Ripest stalks only analyzed.
18	....do		1.0617	3.67	8.76	2.67	
18	....do		1.0570	3.31	8.01	2.68	
20	Wabaunsee	Just in blossom	1.0426	4.24	3.89	2.47	Four stalks weighed 7.5 pounds; gave four pound juice; smallest diameter ⅞, largest 1⅛ inch.
20	Amber	Seed in hardening dough.	1.0674	2.60	11.42	2.38	Smallest diameter ¾, largest ⅞ inch.
20	Early Orange	Head not above the top leaf.	1.0493	3.32	6.27	2.61	Diameter 1⅛ inch.
20	Wabaunsee	Seeds in soft dough	1.0548	3.03	7.07	3.40	Diameter ⅞ inch.
21	Amber	..... do	1.0604	3.09	9.16	1.75	One hill taken.
21	Link's Hybrid	Just headed	1.0502	2.01	7.03	3.35	
22	Orange	......do	1.0405	2.97	4.61	2.52	
22	Amber	Hardening dough	1.0713	2.75	10.97	3.76	
22	....do	......do	1.0674	3.56	10.10	2.74	
23	Orange	Just headed	1.0480	5.35	2.84	2.71	Two stalks weighed 3.5 pounds; juice weighed 1.5 pounds.
23	Amber	Hardening dough	1.0770	2.87	11.97	3.76	Cut 22d; analyzed 23d.
23	....do	......do	1.0753	4.30	10.04	3.86	Do.
23	Orange	Just headed	1.0578	6.30	2.94	4.96	
23	Amber	Two heads dark seed in milk; one head green seed in milk; one head just in blossom.	1.0704	3.25	10.52	3.33	One hill.

Analyses of cane juice—Continued.

Date.	Variety.	State of development.	Specific gravity.	Glucose.	Sucrose.	Solids not sugar.	Remarks.
				Per cent.	*Per cent.*	*Per cent.*	
Aug. 24	Red Liberian	Just headed; not in blossom.	1.0540	4.10	6.38	2.84	
24	East India from Link.	......do	1.0557	3.15	6.09	4.46	
24	Amber	Hardening dough	1.0682	3.60	10.26	2.74	
24	Link, East India.	Just headed, seed in milk.	1.0596	1.95	8.87	3.79	Cut short heads very green.
24	Amber	Hardening dough	1.0656	4.00	8.83	3.17	One hill.
24	Unknown	Just in blossom	1.0472	9.35	0.14	2.21	
25	Amber	Soft dough	1.0634	8.10	3.92	3.30	Stood 36 hours.
25	....do	Some seed in hard, soft, and milk dough.	1.0443	2.99	7.67	4.88	One hill.
25	....do	Hardening dough	1.0609	2.68	9.73	2.49	Do.
25	....do	......do	1.0691	2.74	10.97	3.09	Do.
25	Wabaunsee	Just in blossom	1.0481	7.22	0.72	3.96	Stood one day.
25	Link's Hybrid	Seed just beginning to form.	1.0540	2.66	5.96	4.68	Average of field.
25	Amber		1.0704	3.15	10.54	3.61	
25	....do	In thick milk	1.0665	7.50	6.55	2.70	
27	Orange	Just headed	1.0570	2.81	7.79	3.40	
27	Amber	Seed of top glumes hard dough. Seed base glumes soft dough.	1.0634	2.21	10.22	3.07	
27	....do	Nearly ripe	1.0626	2.20	10.00	3.20	
27	....do	Two stalks in milk. Two stalks in blossom.	1.0587	4.87	5.28	4.25	
27	....do	Hard dough	1.0674	3.20	9.43	3.77	
27	....do	......do	1.0704	3.26	10.68	3.16	
27	....do	Hardening dough	1.0722	2.84	10.62	4.04	
Oct. 18	Orange	Ripe	1.0590	2.24	8.81	3.45	Six days after a freezing frost. Juice from the crusher.
19	....do		1.0591	2.29	8.50	3.71	
20	....do		1.0590	2.45	8.50	3.55	
25	....do		1.0557	1.94	7.88	3.88	Twelve days after the freeze, and after four days of rain and another freeze.
26	....do		1.0540	2.84	7.49	2.97	Same as preceding but one day later.
29	....do		1.0540	3.31	7.10	2.89	
Nov. 2	....do		1.0540	3.70	6.49	3.11	

Copy of report of G. H. Failyer, professor of chemistry in Kansas State Agricultural College, at Manhattan.

EARLY AMBER CANE.

Date.	Condition of cane.	Average height, feet.	Total weight.	Average weight.	Weight of juice.	Per cent. of juice.	Specific gravity.	Total solids, per cent.	Glucose, per cent.	Sucrose, per cent.	Solids not sugar, per cent.
1883.											
Aug. 29	Seed in stiff dough	6.5	6.280	1.047	3.324	52.77	1.062	14.42	2.19	10.67	1.56
30	Seed hardening dough	7.2	6.840	1.140	3.770	55.12	1.060	14.41	2.12	10.15	2.14
Sept. 1	Seed dry, but easily split	6.5	6.806	1.135	3.074	45.17	1.063	15.54	1.13	11.20	3.31
4	Seed split with some difficulty	7.3	6.119	1.020	3.186	52.05	1.059	14.21	2.03	10.30	1.83
8	Split with difficulty	6.0	5.965	0.994	3.291	55.17	1.065	15.46	1.26	11.74	2.46
13	Seed hard and dry	7.4	6.972	1.162	3.465	49.70	1.066	15.85	1.26	13.21	1.38
17	Seed entirely dry	7.5	6.396	1.066	3.059	47.53	1.066	15.48	0.98	13.00	1.50
24	Seed shell out easily	6.4	6.355	1.059	3.080	48.46	1.069	16.38	0.70	12.72	2.96
Oct. 2	......do	7.5	6.051	1.009	3.111	51.25	1.070	16.42	1.35	12.51	2.56

Copy of report of G. H. Failyer, professor of chemistry, &c.—Continued.

LINK'S HYBRID CANE.

Date.	Condition of cane.	Average height, feet.	Total weight.	Average weight.	Weight of juices.	Per cent. of juice.	Specific gravity.	Total solids, per cent.	Glucose, per cent.	Sucrose, per cent.	Solids not sugar, per cent.
1883.											
Aug. 29	Seed in stiff dough	5. 3	5. 130	. 855	2. 677	52. 18	1. 048	11.32	3. 18	6. 21	1. 93
30	Seed hardening dough	6. 1	5. 560	. 927	2. 673	48. 07	1. 052	12. 51	3. 08	7. 44	1. 99
Sept. 1	Seed dry, but easily split	5. 2	4. 396	. 733	1. 885	42. 88	1. 046	11. 14	1. 81?	6. 28	3. 05
4	Seed split with some difficulty	5. 7	5. 572	. 919	2. 680	48. 64	1. 046	10. 92	3. 01	6. 31	1. 60
10	Split with difficulty	4. 8	4. 554	. 756	2. 388	52. 67	1. 040	9. 36	2. 99	3. 98	2. 39
13	Seed hard and dry	6. 3	4. 468	. 745	2. 220	49. 66	1. 048	11. 48	2. 91	6. 57	2. 00

KANSAS ORANGE CANE.

Date.	Condition of cane.	Average height, feet.	Total weight.	Average weight.	Weight of juices.	Per cent. of juice.	Specific gravity.	Total solids, per cent.	Glucose, per cent.	Sucrose, per cent.	Solids not sugar, per cent.
Sept. 10	Seed in stiff dough	6. 5	10. 600	1. 766	5. 711	53. 88	1. 062	15. 13	1. 74	10. 71	2. 68
13	Seed in hardening dough	6. 1	9. 498	1. 899	4. 924	51. 81	1. 066	14. 78	0. 56	11. 62	2. 60
17	Seed dry, but easily split	6. 0	8. 763	1. 753	4. 595	52. 43	1. 056	15. 16	0. 75	12. 30	2. 11
24	Seed hard and split with difficulty.	6. 7	7. 355	1. 839	3. 853	52. 42	1. 061	14. 57	1. 18	10. 47	2. 92

HONDURAS CANE.

Date.	Condition of cane.	Average height, feet.	Total weight.	Average weight.	Weight of juices.	Per cent. of juice.	Specific gravity.	Total solids, per cent.	Glucose, per cent.	Sucrose, per cent.	Solids not sugar, per cent.
Oct. 8.	Seed in hardening dough	8. 1	5. 955	1. 985	3. 417	57. 38	1. 061	......	3. 29	9. 76	....

*Meteorological.**

Date.	Temperature.	Remarks.
	°F.	
April 17	60	Cloudy, high wind.
20	60	Heavy rain during night.
21	56	Terrible wind storm; temperature raised to 75°.
22	54	
27	58–64	Light rain in afternoon; hard rain at night.
28	57–70	First cane appeared.
29	58–60	Light rain during night.
30	56–66	
May 1	64–88–92	High south wind.
2	64–82	Slight rain, with hail.
3	56–72	
4	60–70	
5	60	
6	76–84	
7	72–84	
8	72–86	Very high wind and rain.
9	62	Do.
10	64	
11	56–68	
12	68–76	Heavy rain in the night.
13	70–76	
14	56–74	
15	60–76	
16	66–60	Heavy rain.
17	66–75	Do.
18	64–76	
19	62	Rain.
20	60	
21	52–70	
22	60–76	
23	62	Very high south wind; sand storm cut off 100 acres cane.
24	72–90	Very heavy rain.
25	70–78	
26	62–78	
27	68–80	No wind all day.
28	68	
May 29	68–78	Slight rain; heavy rain in the evening.
30	52	Heavy rain all night.
31	70	
June 1	72–83	Heavy showers through the night.
2	64	
3	57–80	
4	68–78	Light shower 5 to 7 a. m.
5	74–80	
6	78–80	Heavy thunder shower.
7	78–84	
8	78	Rained all night.
9	62	Rain.
10	80	Heavy thunder storm.
11	70	High winds.
12	66	
13	62–85	
14	63–80	
15	77–95	
16	82–95	
17	82–93	
18	76–95	Threatening rain, very close.
19	80–97	
20	80–103	
21	82–103	High south wind.
22	82–102	
23	82–97	
24	90–96	Heavy rain.
25	78–90	
26	76–89	
27	76–88	Cane 3 feet high.
28	76–102	
29	68–105	
30	80–100	
July 1	78–95	
2	80–102	
3	80–98	

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* Record of Prof. M. Swenson, Chemist Kansas Sugar Company, Hutchinson, Kansas.

Meteorological—Continued.

[Record of Prof. M. Swenson, chemist of Kansas Sugar Refining Company, &c.—Continued.]

Date.	Temperature.	Remarks.
July 4	80–97	
5	79–93	
6	77	Heavy rain.
7	68–80	
8	72–83	
9	72–90	
10	76–92	
11	100	
12	82-104	Slight shower.
13	82–94	Slight rain through night.
14	78	Slight shower.
15	80	
16	80	
17	76	Slight rain.
18	78–95	
19	80–95	High winds.
20	80–95	Do.
21	82–93	
22	....	Still warm.
23	....	Do.
24	....	Do.
25	....	Do.
26	104	Heavy rain.
27	80	
28	75–90	
30	70–72	
31	67	Clear and hot.
Aug. 1	78–90	Heavy rain.
2	78	
3	68–76	
4	68	Rain.
5	68	Hard rain.
6	76	Slight rain.
7	79	
8	82	
9	90	Slight rain in night.
10	100	Heavy shower at night.
11	100	
Aug. 12	90	
13	95	
14	85–100	
15	80	Heavy rain and wind; slight injury to cane.
16	82–97	
17	81	
18	78–96	
19	80	
20	76	Rain in the night.
21	77	
22	72	
23	68–80	
24	70–80	
25	74	
26	80–95	
27	64	
28	74	
29	72–85	
30	72	
31	73	High winds.
Sept. 1	75	
2	73	
3	74	Commenced crushing in the afternoon.
4	78–95	
5	70	
6	78	
7	77	
8	62–86	
9	56	
10	60	Light shower.
11	70	Started centrifugals.
13	....	
14	....	
15	....	
16	....	
17	50	

The following table of Kansas meteorology is compiled from the United States signal reports from Leavenworth, Lawrence, Holton, Topeka, Yates Center, Independence, Wellington, and Dodge City, and from the reports of the State Agricultural College at Manhattan, and of the State Normal School at Emporia:

Meteorology of Kansas, 1883.

TEMPERATURE.

Month.	Lawrence.			Topeka.			Dodge City.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	19. 6	47. 0	−14	17. 8	47. 0	−21	22. 1	59. 0	−20
February	27. 9	67. 0	−13	25. 7	65. 0	−21	26. 2	67. 0	−20
March	40. 9	69. 0	16. 0	39. 4	79. 0	9. 0	40. 8	72. 0	15. 0
April	57. 2	90. 0	35. 0	56. 3	84. 0	28. 0	53. 0	85. 0	29. 0
May	62. 0	91. 0	39. 0	62. 0	90. 0	44. 0	60. 5	88. 0	35. 0
June	71. 4	94. 0	48. 0	(*)	95. 0	56. 0	70. 5	97. 0	48. 0
July	(*)	(*)	(*)	78. 0	99. 0	63. 0	76. 2	99. 0	56. 0
August	72. 0	92. 0	52. 0	73. 5	95. 0	54. 0	71. 7	92. 0	53. 0
September	63. 5	91. 0	46. 0	61. 0	94. 0	47. 0	64. 1	97. 0	39. 5
October	52. 7	87. 0	32. 0	53. 5	86. 0	25. 0	50. 8	90. 0	26. 0
November	42. 8	74. 0	14. 0	(*)	74. 0	13. 0	41. 8	73. 0	14. 0
December	33. 7	63. 0	35. 0	33. 1	73. 0	zero.	34. 8	67. 0	2. 0
Means	....	....	....	....	....	....	51. 0	....	....

* No record.

PRECIPITATION.

Month.	Lawrence.	Topeka.	Dodge City.
	Inches.	*Inches.*	*Inches.*
January	0.73	0.50	0.44
February	2.31	3.10	1.42
March	1.28	0.81	0.42
April	2.12	1.60	2.40
May	7.63	6.42	5.41
June	7.73	7.05	4.31
July	(*)	6.52	2.61
August	2.12	4.17	5.66
September	1.25	0.88	1.32
October	6.75	6.14	3.32
November	0.73	0.81	0.12
December	0.77	(*)	1.07
Totals			28.50

*No record.

The following historical notice of the development of the industry in the West is a fitting appendix to the review of the present condition of the sugar interest in Kansas, which has just been given:

HISTORY OF SORGHUM CULTURE IN KANSAS.

The following paper was read by Hon. F. G. Adams before the Kansas State Sorghum Growers' Association, February 14, 1884:

The history of sorghum culture in the United States corresponds, in point of time, with the history of Kansas itself. The settlement of Kansas began in the year 1854. Sorghum was first noticed by the agricultural division of the United States Patent Office in the report of that Department for 1854. Just thirty years ago it was, this winter, that our national seed hunter was studying sorghum in France, and during the same month the people of this country were being excited over the discussion of the question of opening Kansas to settlement. The people of the Southern States were studying how they should add another slave State to the galaxy, while those of the North were strongly opposing such project, and organizing to—

"Cross the prairies as of old
The Pilgrims crossed the sea,
To make the West as they the East,
The homestead of the free."

The population of the new States and Territories of the West have always been large consumers of molasses; this in the first years of settlement, by reason of the lack of fruit and of other necessaries and luxuries, which only come with improved circumstances and conditions of life. Before sorghum sirups came to be introduced New Orleans molasses was in almost universal use throughout the Western States.

When sorghum came to be known as a valuable home-made substitute, it immediately became popular. Every early settler in Kansas remembers that at the first, sugar and molasses were articles of prime necessity here; molasses more than sugar. In the pioneer wagon, tent, or cabin life, molasses served the purposes of butter, of milk, of fruit, and of sundry other condiments. We all came to Kansas by the way of the Missouri River, and all outfitted more or less at Saint Louis. No one failed to bring along a jug, ten gallon keg, or half barrel of molasses; and whatever was the quantity, it was one of the first articles of the supplies to fail.

The first seeds of the sorghum distributed from the United States Patent Office were procured by the Commissioner in France in 1854 and were planted in 1855. After two years of experimental cultivation action was taken for an abundant supply of seeds for planting in 1857. In his report for 1856 (Patent Office Report, 1856, page 5), under date of February 17, 1857, the Commissioner says: "There seems a reasonable probability that it (the Chinese sugar-cane) will furnish almost every portion of the United States with means of producing, economically, all the sugar, or at least the sirup, which may be needed for domestic consumption, and even, perhaps, much for exportation. Steps have been taken the past season to supply the means to extend the cultivation of this product into every portion of the country. This office procured, in the first instance, 175 bushels of the seed which had been grown in this neighborhood, but finding that the demand was far from being supplied, 100 bushels more have been recently ordered from France. As every bushel contains seed sufficient to plant more than thirty acres of ground the whole amount distributed from this office during the present season will plant more than 8,000 acres; and, as each acre will yield on an average some 40 bushels of seed, there will probably be grown during the present year enough to plant more than ten million acres in 1858, should it all be harvested for that purpose; and this is independent of all which may be introduced from other sources. The country may, therefore, be reasonably expected to be fully supplied with this seed after the present season, and further distribution thereof from this office will not be necessary.

[It may be a matter worthy of note here that, in his report to the Commissioner of Patents in 1854, and published in the Commissioner's Report for that year, Mr. D. J. Brown states that Mr. Leonard Wray, who had given much attention to the cultivation, and had experimented upon the juice of the sorghum in Natal, Africa, informed him that in the neighborhood of Natal the Zulu-Kaffre, after gathering the canes of the plant, preserved them for a long time by burying the stalks in the ground, notwithstanding the climate of their country is very warm and damp. Does not this suggest that in Kansas the season of manufacture might be much prolonged by placing the canes in receptacles similar to the silo?]

When first noticed in the Patent Office Report, in 1854, sorghum had not been introduced into the United States, but an agent of the Government furnished that year for the report some account of the cultivation of the plant in France, where it had been introduced some four or five years before. A small quantity of seed was then procured by the Commissioner and given to a few persons in different portions of this country for planting in 1855. The first reports made of experiments in the culture appeared in the Commissioner's Report for 1855, which was published in 1856. These reports of experiments are curious, as showing that the cultivation and manufacture of sorghum in this country was, that year, a great novelty and *wholly* experimental. No instructions as to mode of planting, cultivation, or use had accompanied the packages of seeds received. These were simply the words printed upon the packages: "Good for fodder, green or dry, and for making sugar." Mr. Brown, the European agent, in his report had stated that the great object sought in France, in the cultivation of this plant, was the juice contained in the stalk; "which furnishes," he says, "three temporary products—sugar, which is identical with that of cane sugar, alcohol, and a fermented drink analogous to cider."

The reports of experiments made in 1855 were from seven States—Illinois, Minnesota, Missouri, New York, Pennsylvania, South Carolina, and Virginia. All showed favorable results as to sorghum as a forage plant, and in two instances promising results coming from rude experiments in making molasses.

That year, 1855, was the first year of crop raising among the new settlers of Kansas. None of these settlers probably received seeds for that year's planting, and the newspapers had not then begun to speak of sorghum. No popular information seems to have appeared on the subject before 1856. My own first definite recollection of the plant is from having grown a few stalks in my own garden, in the city of Atchison, in

1858, yet no doubt it was grown in Kansas in 1857, and possibly in 1856. The enterprising and needy population of Kansas Territory of that day may well be supposed to have quickly seized upon an article of cultivation which promised to supply them at the cost of little more than their own labor with an article of so great use and economy, heretofore a heavy drain upon their scanty resources.

The first mention of sorghum made in a Kansas newspaper, so far as has come under my observation, is found in the columns of the Herald of Freedom, published at Lawrence, of date November 22, 1856. This was the second year of the distribution of seeds from the Patent Office, and at the close of the second experimental year in this country. This mention was not concerning a Kansas experiment, but one made that year in Bucks County, Pennsylvania. In this, details are given in such manner as to imply that the subject was entirely a new one. The results shown were favorable as to sorghum as a fodder plant; nothing as to sugar or molasses.

In the next issue of this Kansas paper, that of December 6, 1856, is an article copied from that then leading agricultural paper in the West, the Prairie Farmer, Chicago, in which, under the head of "Sugar Millet," a writer says: "As it seems desirable to obtain all the information possible in reference to the sugar millet, or Chinese sugar-cane, I give such facts as I have been able to obtain in reference to my own experience." The writer had planted in his irrigated garden in Illinois a square rod of ground, with a package of seed which had been sent him from the Patent Office; planting late in the season, for at first he had thought of doing nothing with the seed, considering it rather in the light of a hoax. After the cane had grown, he let the frost nip it. He then cut it down and threw it to one side in order to plant the patch to strawberries. After that, and after the cane had lain ten days in a heap, seeing in a newspaper the account given by Governor Hammond of his experiment the year before in South Carolina, the Illinois writer took some of his canes, cut them into 3-inch pieces, and put them through his cider mill and then through his cider press, thus getting out seven quarts of juice. This he evaporated, and obtained a quart of a fair specimen of molasses, cleansing with soda and a little milk. He seemed to consider his experiment as a promising one.

Our Kansas Herald of Freedom of December 20, 1856, has a scrap from a Nebraska paper, in which the editor acknowledges the receipt of a small quantity of molasses manufactured from sorghum cane grown in that Territory. As Kansas was far ahead of Nebraska in most everything in those times, not excepting the matter of political commotion within her midst, it is not to be doubted that she was, at the least, even with her neighbor on the north as to time in sorghum planting, and it is expected that it will yet be found that sorghum was grown in Kansas in the year 1858.

At the close of the reading of this paper before the Sorghum Association, Mr. F. W. Giles, of Topeka, arose and stated that in the autumn of 1855, being then postmaster of Topeka, he received from the United States Patent Office a small quantity of the Chinese sugar-cane seed, as it was then called, and inthe spring of 1856, planted it upon his farm near Topeka. The growth of the plant was watched with deep interest, and when it had attained maturity it presented a spectacle so novel, and so suggestive of future possibilities to the new Territory, that he contributed an item upon the subject to the Kansas Freeman, a newspaper then published at Topeka. In the succeeding winter, great interest being felt throughout the country as to the results of the new cane culture, he gave information that he had successfully grown the plant, and had saved a small quantity of the seed, which he offered to persons who might desire to secure it. Some forty small packages, containing an ounce of seed each, were sent to the southern portions of the Territory for distribution, and a pound or more to the vicinity of Fort Riley. Other parcels were sent to Atchison and to Lawrence. Beginning with 1857, sorghum sirup has been a product among the farmers of Shawnee County continuously, to this time.

Mr. Giles stated that he had not been informed of any other instance of the growth of sugar cane in Kansas in 1856, and he thought it probable that the few hours devoted by him to its culture, and the subsequent distribution of seed by him, may have been the true beginning of the industry in Kansas.

The issue of the Kansas Herald of Freedom of December 27, 1856, contains as far as I know, the first *editorial* article on this subject ever written and published in Kansas. This article smacks of politics a little, and makes a criticism of the sugar tariff, and of slaveholding. "We pay," the editor says, "for sugar now from 16 to 22 cents per pound; for molasses from $1 to $1.20 per gallon. In order to keep up the Louisiana sugar planters, we have to pay a duty of 30 per cent. ad valorem on all imported sugar. The expenses of sweetening a family has really become a very considerable item in housekeeping. The prospects of getting it cheaper are not very flattering, if we depend upon our Southern planters to produce it. Their annual crop has dwindled from 470,000 hogsheads per annum to 120,000, nearly three-quarters less than it was ten years ago. This is a strong argument for the repeal of the tariff, which would no doubt be done, were it not for the interest of the slaveholder to retain it. But we have the tariff, and it will probably be retained for their benefit. This may in the end be fortunate for the country, for it will stimulate very considerably the cultivation of the *Chinese sugar cane.* This is destined, at no distant day, to be one of the staple productions of Kansas, and perhaps of all the Middle States." And here the editor remarks, in reference to Kansas, what twenty-seven years of cultivation since has well demonstrated, certainly so as applying what he said to the climate of Kansas. "The soil of Kansas," he says, "is remarkably adapted to the favorable growth of this plant. The spontaneous vegetation indicates a warm alkaline soil, free from acids, and well calculated to secrete saccharine, in plants favorable to elaborate it. This is seen in the superior sweetness of our sugar beets, watermelons, and sweet potatoes. The climate is also favorable; it being warm and dry."

And the next spring, 1857, the cultivation of sorghum was no doubt well begun in Kansas. In the issue of the Herald of Freedom of April 11, 1857, the editor says, in a paragraph under the head of "New articles of agriculture," as if there had been known to him no cultivation of sorghum in Kansas before that time: "Several persons are going into the sugar business this season sufficiently large to test the value of the new sugar plant. Caution is necessary at first in order that persons may not lose too much by failure. Experience is necessary."

By 1860 Kansas, with a population of a little over 100,000, produced nearly 88,000 gallons of molasses, or four-fifths of a gallon to each inhabitant. Though the year 1860 was one of unparalleled drought in Kansas, but four States exceeded our Territory that year in the production of this article in ratio of population. These States were Indiana, Iowa, Ohio, and Tennessee. In 1870, with a population of about 350,000, Kansas produced, in round numbers, 450,000 gallons of sorghum sirup, or 1¼ gallons to the inhabitant. But three other States—Indiana, Kentucky, and Tennessee—equaled this ratio of production. In 1880 Kansas, with a population of not quite 1,000,000, produced 3,250,000 gallons; and in 1883 the production was over 4½ gallons of sorghum sirup to the individual inhabitant; and the same year there was produced within the State, as estimated, nearly 500,000 pounds of sorghum sugar.

The high price of sugar and molasses during the war greatly stimulated the cultivation of sorghum. But a drought in 1863 in the Western States, followed by an unusually severe frost before the plants were ripe, nearly destroyed the sorghum crop, and greatly discouraged and lessened the planting in most of the Western States for some years thereafter. Kansas was, however, comparatively exempt from the calamity of 1863.

At the annual meeting of the Kansas State Agricultural Society at Topeka, in January, 1864, among others who brought in samples of sorghum products for exhibition, of the crop of 1863, Hon. Charles B. Lines, of Wabaunsee County, exhibited some samples of sorghum sugar of superior quality manufactured by him. Mr. Lines gave an account of his experience in sorghum cultivation and manufacture in Kansas, running through a period of six years. This account was published in the Kansas Farmer of April, 1864. His first seed, planted in 1858, was procured direct from the Patent Office at Washington. For that and several subsequent years his was the usual early experience; that from the use of wooden mills and of evaporating pans of the most primitive construction. By 1862 he had an iron mill and Cook's patent evaporator, and results were good. He manufactured for most of the farmers of his neighborhood, for by that time, twenty-two years ago, and only eight years after the introduction of sorghum into this country, almost every farmer in Kansas had his sorghum patch; and it was quite generally raised for making sirup, one mill and evaporator doing service for a neighborhood.

In 1863 Mr. Lines planted both sorghum and imphee, and that year he obtained sugar from the canes of both. As to the imphee sirup, evaporated in the usual way, it was placed in barrels in a cellar; and, after a few days, an examination revealed the fact that the barrels were more than half filled with sugar. The sirup was then withdrawn and the sugar placed in common salt barrels, with the heads perforated with gimlet-holes, and set over a tub to drain. The result in a few days was a beautiful article of clean, dry sugar. This was in a cool cellar, and in the month of October, and yet about one-half of the mass in each barrel was well drained and fit for table use. From the three barrels of imphee sirup not less than 300 pounds of sugar were obtained. But while all the imphee manufactured by Mr. Lines grained freely, but one barrel out of ten of the sorghum produced any considerable amount of sugar.

Mr. Lines, in his paper presented to the Agricultural Society, referred to the existence at that time of a State Sorgo Association in Ohio, and stated that persons who had examined the more than fifty samples of sugar collected from various parts of that State by that association, testified that they did not see a single specimen that would begin to compare with those exhibited by him at the Kansas meeting, and produced by him in Wabaunsee County, and he said:

> This state of facts can only be explained upon the supposition that our soil and climate are better adapted to this culture; for certainly the farmers of Ohio must have possessed greater facilities than we have enjoyed. But, without reference to soil, it is obvious that the more highly rarified condition of the autumn in Kansas is pre-eminently adapted to the concentration of the saccharine element and the process of granulation, which gives us greatly the advantage and satisfactorily explains the whole matter. Well, then, may we congratulate ourselves and the farmers of our State that a new and broad field is open to our enterprise. Heretofore our supplies of sugar and molasses have come to us chiefly from the plantations of Louisiana, the fruit of the unrequited toil of the oppressed bondmen and women of that region.

And he concludes with this prophetic remark:

> Hereafter, if the auspicious omens now opening before us are justly regarded as significant of successful results, a portion of our broad prairies will rapidly be converted into sugar plantations, machinery for its manufacture propelled by steam become common in all parts of our State, and this great staple will be manufactured by the intelligent free labor of our people in quantities vastly beyond our need for home consumption.

But it is known to all how these accidental or phenomenal crystalizations in those early times excited hopes which were not realized, and how experiment after experiment, kept up through many years, failed to bring reliable and satisfactory results. It is known to all that sorghum sirup failed to become established as a popular article for table use, and that until recently it may be said to have maintained a place in manufacture, for use only as a substitute for something better where necessity compelled it. Yet through all these years there have been those who, patiently and with faith, labored to solve the problem of sorghum sugar. And now all believe it is solved. Now the predictions of the most sanguine of the early experimenters are beginning to be realized, and we have a near future before us of seeing Kansas a great sugar-growing State, the foremost State of all. The later facts as to this industry and as to the recent developments in the manufacture of sugar, and of better qualities of sorghum sirup, have been so fully set forth in the admirable reports of the Kansas State Board of

Agriculture, in the Kansas Farmer, and other publications of the State, that it is not necessary to speak of them here.

Anything like complete information as to the history of the sorghum production in Kansas would be impossible without great research and much inquiry among the inhabitants. Time has not permitted me to bestow this work upon the subject in the preparation of this paper. What has been here presented may possibly serve the temporary purpose of the gentlemen who laid out the work of this meeting, and may aid the future historian in more extended inquiries.

SORGHUM IN ITALY.*

EXPERIMENTS MADE UNDER THE CARE OF THE MINISTER OF AGRICULTURE.

"The sorghum Amber cane of Minnesota, so called on account of the amber color of its seed, is a variety of our common broom-corn (*Sorghum saccharatum*), from which, while it does not differ in its specific character, it is easily recognizable by not having the interior of the stalk filled with a white and dry pith, but rich in saccharine juice. This close affinity is the cause of the easy hybridization of Amber cane, and when cultivated in the vicinity of the broom-corn of our fields there is danger, after some lapse of time, of the stalks becoming dry and poor in saccharine substance.

Whilst the *Sorghum saccharatum* grows spontaneously in the East Indies and in Arabia, the variety we are speaking of came to us from America, where it is called Early Amber. In 1856 and 1857 † seeds of various kinds of sorghum were introduced into the United States from France and England, and under the influence of the climate and of cultivation they have been modified, and multiplied.

In the experiments made at Washington upon the saccharine richness of sorghum in 1881, twelve States of the Union figured as having furnished seeds of thirty-four varieties. In 1877 it was found that in the juice of Minnesota Amber cane there was a large deposit of sucrose, and from that time accurate investigations were commenced in America on the subject.

Also in Italy, in the years 1880 and 1881, experiments were made under the care of Commander Chizzolini in Mantua, of Mr. Sacerdoti in Modena, of the Technical Institute of Viterbo, in the district of Viterbo and of this department in the fields set apart for experiments of the agricultural stations scattered throughout various provinces. But the difference found in the results of culture and in those of saccharometry rendered manifest the utility of new studies that should show clearly on what conditions this new saccharine plant could be advantageously introduced into our country for the purpose of extracting its sugar or for alcoholization, and likewise as fodder for cattle.

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* Annali di Agricultura; Esperimenti Culturali Sul Sorgo Ambrato.

† These dates are erroneous. See Report of Botanist.—R.

Therefore the Department, in accordance with the resolution of the Chamber, which requested the Government to promote, by every means, the culture of sorghum and the beet-root, decided that a new cultural experiment should be made in 1882, and in the month of March distributed Amber-sorghum seed to all the agrarian stations of Udine, Forli, Firenze, Pnoma, Caserta, Palermo, to the agrarian schools of Pesaro, Scerni, Portici, Lecce, Catanzarò, to the Zootechnical School of Oil-making of Bari, to the Agricultural Colony of San Martino near Palermo, to the Technical Institute of Viterbo, to the Society of Acclimation of Palermo, and to Professor Missaghi, president of the Vine Culture Commission of Cagliari.

Beside inquiring into the influence exerted by the various climates of Italy upon the cultivation of Amber sorghum, it was desired to know what difference of results would be obtained by using seed imported directly from Minnesota and the seed reproduced in Italy, which is the most advantageous mode of sowing, to what extent the richness of sucrose varies in the different stages of the vegetable period, and what is the most suitable time for the harvest; in what proportions and with what degree of rapidity the conversion of sucrose into glucose takes place in the gathered stalks; in what climates the cultivation of Amber sorghum can be carried on with more advantage than that of maize or beets.

The method of cultivation of the beets and sorghum was written out in detail, so that all the experiments made in different parts of the kingdom should be carried on under the same conditions.

Samples for analyses were taken at stated times and by uniform methods; the analyses were all carried on in the same way, and hence the results are strictly comparable.

The method of analysis was as follows:

CHEMICAL RESEARCHES ON SORGHUM.

The juice was extracted by grating the cane and squeezing the pulp obtained by means of a good hand-press. It was found that by operating in this manner there remained in the pulp from one-fifth to one-sixth of the juice, since the sugar which was obtained by diffusion in water varied from one-fifth to one-fourth that contained in the juice extracted.

The glucose and sucrose were determined with the cupropotassic reagent of Fehling, the results being controlled with solutions of sugar and with the optical saccharometer.

Results of experiments made by the Zootecchnic School in Reggio, by Professors Zanelli and Spallanzani.

TABLE I.

Date of harvest.	Date of analysis.	Mean of each cane.			Juice extracted to weight of cane.	Specific gravity of juice at 15° C.
		Length.	Diameter.	Weight.		
		Meters.	*Millimeters.*	*Grams.*	*Per cent.*	
Sept. 7	Sept. 15	2.10	18.0	485.0	58.30	1.072
7	27	1.85	21.0	429.5	56.84	1.083
21	27	1.75	22.0	519.5	55.52	1.092
21	Oct. 17	1.70	17.0	457.0	52.72	1.107

TABLE II.

Date of harvest.	Date of analysis of juice.	Juice.		Sum of two sugars.	Non-sugars.	Coefficient of purity.
		Glucose.	Sucrose.			
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	
Sept. 7	Sept. 15	2.20	16.49	18.69	....	....
7	27	3.75	15.43	19.18	....	....
21	27	5.96	15.95	21.91	6.30	56.54
21	Oct. 17	7.96	7.09	15.05	9.84	24.46

TABLE III.

Date of harvest.	Date of analysis.	Juice extracted per 100 of cane.	Result per 100—			Part of the cane analyzed.
			Of glucose.	Of sucrose.	Of both sugars.	
Sept. 21	Oct. 2	50.76	10.65	13.63	24.28	Lower part.
21	2	32.57	6.85	17.57	24.42	Upper part.
21	5	66.34	7.68	9.46	17.14	External part.
21	5	53.48	6.09	5.51	11.60	Internal part.

To sum up from the observations and the comparisons on which the preceding investigations bear, we come to these conclusions:

1. The culture of Amber sugar-cane may very probably give, in our country, a rich yield of crystallizable sugar, as it does in that American State (Minnesota) from which the plant was originally brought.

2. By prolonging the time which intervenes between the harvest of the sorghum cane and its analysis, the juice obtainable therefrom and its percentage in sucrose diminishes, while there is not always an increase of glucose. Perhaps, by putting the cane under the ground and moistening it before this is done, the losses may be considerably reduced.

3. The upper internodes and the peripheric strata of the cane seem to yield a greater abundance of saccharose than the lower internodes and the central strata, so that it would seem advisable not to sow thick and to cultivate sorghum, just like beets, in such a way as to obtain the product of an average and suitable size.

4. The beets were not equal as regarded quality. The unusual condition of the season and the tardy harvest were probably the causes of their failure.

The fact that the sorghum did better, in spite of the same unfavorable climatic conditions and the same condition of cultivation, is a circumstance to be considered for the purpose of encouraging the manufacture of sugar.

Studies on sorghum intended to demonstrate the utility of its cultivation in a chemico-agricultural point of view should be repeated in order to ascertain the changes which take place in its constitution, not at previously fixed times, but continually, in order accurately to ascertain the phase of development in which the gathering may take place with most advantage, and to determine what appearances accompany that phase and the peculiarities of constitution which correspond thereto, and which are most easily observed."

The report of the Minister of Agriculture next gives tables of the results of the culture of sorghum, and from them the following conclusions are drawn:

"CONCLUSIONS AS TO THE SOIL INFERRED FROM CULTURAL OBSERVATIONS.

1. The cultivation of sorghum, even in lands of moderate richness, succeeds very well in the same conditions as that of common maize, and when the chemico-industrial question is settled there will be nothing to fear in this direction.

2. The seed of acclimated sorghum gives a larger yield and a more vigorous plant than the original seed.

3. For the quantity of the yield sowing in line is preferable to sowing in tufts.

4. The yield of the stalks of the sorghum increases in quantity from the blossoming to the fecundation and the maturation of the seed; then it diminishes somewhat, and increases again after the autumnal rains.

5. In grounds tending to form a crust, the depth of planting must not be greater for sorghum than two centimeters, the depth of three centimeters having been found excessive even in the present case. Besides, as to the sowing, it is to be observed that it should not take place too early; it should be delayed until a stated season in the spring, from the first to the last of May. To sow earlier, with the unexpected return of cold, sorghum suffers, and in any event is injured considerably.

6. The enemies by which sorghum has been heretofore attacked are insects (which are easily destroyed by insect-powder made from tobacco) and birds. It is further to be observed, first, that whilst the leaf of the beet is often found injurious to animals fed upon it, causing among other things diarrhea, the sorghum leaf, on the contrary, makes good fodder;

second, that the cultivation of the sorghum is more rapid and leaves the ground free sooner.

7. Likewise the grain of the sorghum furnishes a good food for cattle, as seen by the following analysis:

Analysis of sorghum seed.

TABLE IV.

	Ripe seed.	Half ripe seed.
One hundred parts of seed contain:		
Moisture	8.210	10.620
Ashes	2.113	2.340
Albuminous matter	13.470	12.300
Fat	3.164	2.593
Starch and sugar	70.320	68.980
Fiber, &c	1.993	2.134

METHOD OF HARVESTING.

The harvest of Amber sorghum was made by cutting the stalks on a level with the ground, and was performed in four different periods, divided as follows: 1st. One quarter of each division immediately after blossoming. 2d. Another quarter one month after blossoming. 3d. Another quarter shortly after the ripening of the seed. 4th. The last quarter fifteen days later, unless the different origins of the seed or the different cultivations made in the drills or hills delay or hasten very much the blossoming or the ripening of the fruit; the gathering should take place on the same day in all the divisions.

For each gathering and each division, the following things were examined separately: (*a*) the weight of the seed heads; (*b*) the weight of the leaves; (*c*) the weight of the stalks (*d*) for the third and the fourth gatherings, the weight and the measure of the cleansed grain were also noted.

The stalks being gathered, the extraction of the juice and the saccharometric tests were made at three different times, that is: 1st, the day after the harvest; 2d, ten days after the harvest; 3d, one month after the harvest, keeping account (*a*) of the proportion of weight between the juice and the stalks, (*b*) of the saccharine richness of the juice, (*c*) of the proportion between glucose and sucrose.

PROCESS EMPLOYED TO DETERMINE THE AMOUNT OF SACCHARINE MATTER OF SORGHUM.

The saccharometric determinations were made with Fehling's cupro-ammoniac reagent, the juice being first treated with basic acetate of lead, the excess of which was precipitated with carbonate of soda.

Here are the results obtained, at Modena, under direction of Professor Pirotta:

Result of saccharometric determinations.

TABLE V.

First harvest.

Plat of ground.	Estimate of sugar.	Quantity of stalks.	Juice obtained.		Quantity per 100 of juice in—			Density of juice
			Absolute.	Per 100.	Saccharine matter.	Sucrose.	Glucose.	
		Kilograms.	*Kilograms.*	*Kilograms.*				
First	I	1. 475	0. 900	61. 01	13. 82	8. 67	5. 15	1. 0600
	II	1. 550	0. 950	61. 61	14. 02	6. 62	7. 40	1. 0670
	III	1. 380	0. 830	60. 14	18. 75	13. 70	5. 05	1. 0905
Second...	I	1. 400	0. 750	53. 50	13. 00	7. 64	5. 36	1. 0590
	II	1. 475	0. 875	59. 32	15. 30	8. 20	7. 10	1. 0710
	III	1. 055	0. 505	47. 86	21. 26	15. 42	5. 84	1. 1010
Third....	I	1. 500	0. 900	60. 00	5. 86	1. 94	3. 92	1. 0355
	II	0. 800	0. 500	62, 50	14. 90	7. 17	7. 73	1. 0710
	III	0. 485	0. 260	53. 60	17. 70	8. 14	9. 56	1. 0880
Fourth ..	I	0. 950	0. 600	63. 15	10. 23	5. 23	5. 00	1. 0500
	II	0. 750	0. 475	63. 83	13. 88	6. 15	7. 73	1. 0660
	III	0. 530	0. 240	45. 28	18. 01	9. 53	8. 48	1. 0955

TABLE VI.

Second harvest.

Plat of ground.	Estimate of sugar.	Quantity of stalks.	Juice obtained.		Quantity per 100 of juice in—			Density of juice.
			Absolute.	Per 100.	Saccharine matter.	Sucrose.	Glucose.	
		Kilograms.	*Kilograms.*	*Kilograms.*				
First	I........	1. 600	0. 950	59. 33	17. 03	14. 04	2. 99	1. 0810
	II..........	1. 450	0. 940	64. 82	20. 61	14. 38	6. 23	1. 0960
	III..........	1. 025	0. 550	53. 64	23. 56	15. 06	8. 50	1. 1080
Second...	I...........	1. 725	1. 025	59. 41	18. 48	16. 04	2. 44	1. 0840
	II...........	1. 620	0. 970	59. 50	20. 43	14. 59	5. 84	1. 0930
	III.........	1. 250	0. 730	58. 40	19. 10	12. 40	6. 70	1. 1100
Third....	I...........	1. 260	0. 810	64. 28	17. 74	14. 58	3. 16	1. 0820
	II	1. 540	0. 980	63. 63	19. 52	13. 34	6. 18	1. 0895
	III..........	1. 150	0. 600	52. 17	21. 65	16. 12	5. 53	1. 1015
Fourth ..	I...........	1. 560	0. 960	61. 53	19. 04	16. 64	2. 40	1. 0870
	II	1. 325	0. 825	62. 26	19. 91	14. 95	4. 96	1 0980
	III.......	1. 225	0. 675	55. 10	22. 66	15. 96	6. 70	1. 1050

TABLE VII.

Third harvest.

Plat of ground.	Estimate of sugar.	Quantity of stalks.	Juice obtained.		Quantity per 100 of juice in—			Density of juice.
			Absolute.	Per 100.	Saccharine matter.	Sucrose.	Glucose.	
		Kilograms.	*Kilograms.*	*Kilograms.*				
First	I	1. 425	0. 900	63. 15	17. 59	15. 04	2. 55	1. 0800
	II	1. 230	0. 840	68. 29	18. 45	13. 09	5. 36	1. 0900
	III	1. 915	0. 505	55. 19	24. 06	14. 14	9. 92	1. 1160
Second ..	I	1. 475	0. 865	58. 64	17. 92	16. 20	1. 72	1. 0850
	II	1. 260	0. 780	61. 90	21. 25	16. 83	4. 42	1. 0970
	III	1. 100	0. 540	48. 18	25. 91	13. 45	12. 46	1. 1325
Third....	I	1. 550	1. 035	66. 77	17. 69	15. 63	2. 06	1. 0820
	II	1. 430	0. 750	52. 44	20. 16	14. 80	5. 26	1. 0995
	III	1. 000	0. 575	57. 50	24. 76	14. 26	10. 50	1. 1175
Fourth ..	I	1. 450	0. 953	65. 51	17. 95	15. 76	2. 19	1. 0840
	II	1. 210	0. 710	58. 67	20. 62	15. 52	5. 10	1. 0995
	III	1. 050	0. 640	60. 95	24. 65	16. 53	8. 12	1. 1130

TABLE VIII.

Fourth harvest.

Plat of ground.	Estimate of sugar.	Quantity of stalks.	Juice obtained.		Quantity per 100 of juice in—			Density of juice.
			Absolute.	Per 100.	Saccharine matter.	Sucrose.	Glucose.	
		Kilograms.	*Kilograms.*	*Kilograms.*				
First	I	1.225	0.725	59.18	19.38	17.48	1.90	1.0890
	II	1.000	0.540	54.00	20.70	16.38	4.32	1.1015
	III	0.915	0.535	58.46	24.56	18.03	6.53	1.1150
Second	I	1.400	0.840	60.00	19.62	18.38	1.24	1.0910
	II	1.220	0.740	60.65	20.81	17.12	3.69	1.0980
	III	0.875	0.405	46.26	26.89	19.24	7.65	1.1400
Third	I	1.475	0.905	61.35	18.81	16.90	1.91	1.0865
	II	1.150	0.700	60.86	22.53	18.25	4.28	1.1045
	III	1.000	0.460	46.00	26.34	18.93	7.41	1.1138
Fourth	I	1.275	0.785	61.57	19.35	17.89	1.46	1.0905
	II	1.175	0.690	58.72	21.36	18.40	2.96	1.1005
	III	1.150	0.620	53.90	25.79	19.09	6.70	1.1160

CONCLUSIONS.

1. The percentage of the juice remains almost equal in the first two experiments of each gathering (the difference being due to the difficulty of having in each gathering canes of exactly the same size). It diminishes considerably in the third experiment, doubtless because the canes remain for some time detached from their roots, deprived of their leaves and exposed to the air.

2. The quantity of juice, of sucrose, and glucose is not sensibly different in canes grown from the original seed and from the reproduced seed.

3. The quantity of sucrose always increases in the experiments of the first and the last gathering all of the divisions; in those of the second and the third the quantity varies without rule according to the various experiments.

4. The quantity of glucose diminishes in all the experiments from the first to the last gathering, with the exception of the third.

5. The quantity of sucrose is always the most abundant in the last experiment of the last gathering.

6. The quantity of glucose is the most abundant in the third experiment of the third gathering of each division.

7. Both the sucrose and the glucose increase in quantity from the first to the third experiment in each gathering and in each division.

8. The smallest quantity of sucrose is found in the experiments of the first gathering, but it always increases in the third experiment of the first gathering.

9. The difference in the sucrose is largest between the experiments of the third and the fourth, and smallest between those of the second and the third gathering.

As to the ratio between the quantity of sucrose and of glucose contained in the juice and the time of vegetation of the sorghum, the experience of this year permits us to state that:

1st. The quantity of sucrose is smallest immediately after the blossoming, while relatively that of the glucose is largest.

2d. The quantity of sucrose is largest ten days after the maturation of the seed, while at the same time the quantity of glucose is smallest, decreasing nearly in proportion to the increase of the sucrose.

3d. The quantity of sucrose in the gatherings made one month after the blossoming, and as soon as the maturation of seeds is completed, is almost equal in the two gatherings, and much greater than that of the gathering made immediately after the blossoming.

The quantity of glucose, which in the first two gatherings above referred to remain almost equal, diminishes considerably in that made one month after the blossoming. These results agree with those obtained in the United States. Only the quantity of sucrose and the density of the juice were always somewhat greater in this experiment than those found in America."

The results of the experiments at the other stations in Italy are equally as interesting. The sorghum plant appears to thrive much better in Italy than in this country, and the percentage of both sugars in the juice reached in some of the experiments 26. These cases were in canes which were not analyzed until a month after cutting, and it is but fair to suppose that the juice had become somewhat concentrated by evaporation. It is also noticed that sorghum canes retain their sucrose for a longer time than with us, in at least two cases the percentage of this sugar being 19 one month after the canes were cut. It would have been of interest had the Italian Minister of Agriculture told us how the canes were preserved for so long a time. In absence of any definite statement, it is probably safe to say that these canes were kept under ground.

The remarkable results of the Italian experiments indicate that in this country our experiments have not extended far enough south to secure the best conditions of growth. In the great majority of cases the Italian canes that were cut after the seed were ripe, and analyzed on the following day, showed a richness in available sugars which is fully equal to the best tropical canes.

METHODS OF ANALYSES PRACTICED IN THIS DIVISION WITH JUICES (RAW AND DEFECATED), SEMI-SIRUP, SIRUP, AND MELADA.

SUCROSE.

Sucrose was determined by double polarization in a large Laurent shadow saccharimeter. The mean percentage of sucrose in all the raw juices examined was—

	Per cent.
By direct polarization	8.72
After inversion	8.38
In the defecated juice:	
By direct polarization	8.91
After inversion	8.62

	Per cent.
In semi-sirup:	
By direct polarization	29.83
After inversion	30.08
In sirup and molasses:	
By direct polarization	39.80
After inversion	38.96
In meladas:	
By direct polarization	51.25
After inversion	48.39
In sugars:	
By direct polarization	90.60
After inversion	88.59

REDUCING SUGARS.

These determinations were also made in duplicate, viz:

(1.) By titration with Fehling's solution, using potassium ferro-cyanide to determine the end of the reaction.

(2.) By the permanganate method described in Annual Report of Department of Agriculture for 1880, pp. 42, 43.

For raw juices the mean of all the determinations was—

	Per cent.
By titration with Fehling's solution	4.31
With permanganate	4.26
For defecated juice:	
With Fehling's solution	4.26
With permanganate	4.28
For semi-sirup:	
With Fehling's solution	16.20
With permanganate	16.48
For molasses and sirups:	
With Fehling's solution	25.69
With permanganate	28.11
For sugars:	
With Fehling's solution	3.68
With permanganate	3.81

SUCROSE IN DIFFUSION WASTE WATERS AND PULPS.

In these substances, when the percentage of sucrose was often less than 1 per cent., only direct polarizations were made.

From 50 to 100 grams of the material were used (in 100^{cm} volume), and the polariscopic readings made in tubes 500^{mm} in length.

OTHER SUGARS IN DITTO.

The waste water was titrated without dilution with Fehling's solution of one-tenth strength. For pulps 150 grams were weighed into a tared dish, the weight made up with water to 750 grams. The mixture was then boiled for an hour, water being added from time to time to make up for loss of evaporation. After cooling, the original weight was restored by adding the small quantity of water necessary. After filtering, a measured portion of the filtrate was titrated with one-tenth Fehling's solution.

In all titrations with copper solutions I determine the end of the process by filtering a few drops of the liquid into a white dish (porcelain crucible, or lid) in which is previously placed a drop of potassium ferro-cyanide acidified with acetic acid. In order to be exact, the filtration should be as rapid as possible and at a high temperature.

The only way in which I have been able to secure these two conditions is as follows: A glass tube 10^{cm} to 20^{cm} in length and 20^{mm} to 30^{mm} in diameter is softened at one end and pressed on a block of wood. This produces a rim around the end, over which a piece of fine linen can be tied with linen thread. This having been done, the covered end of the tube is placed in a beaker containing asbestos pulp suspended in water. About one-half cubic centimeter of water is sucked into the tube. This leaves the linen diaphragm covered with a film of asbestos. The water is now poured out and the tube is ready for use. When the copper appears reduced, the end of the tube is placed in the dish and a few drops of the liquid sucked into it. This liquid is turned at once into the porcelain dish containing the ferro-cyanide. The end of the reaction can be determined in this way speedily and with the greatest accuracy. The tubes after use are dipped into very dilute nitric acid, and after washing with pure water are again ready for use. Ten or twenty of them should be kept in working order.

After having used this method (first more than three years ago) in many thousand determinations, I consider it one of the best means yet devised for indicating the point of exact saturation.*

ANALYSES OF CANES AND BAGASSES.

The direct determination of sugars in the canes is attended with many difficulties. The fibrous structure of the canes and their hard points render their reduction to a fine pulp almost impossible. In the following analyses from 25 to 50 kilograms of the canes and 10 to 20 kilograms of the bagasse were passed through the cane-cutter preparatory to sampling. An equal quantity of the canes, as much like the preceding as possible, was passed through the experimental mill and the juice subjected to analysis. The details of the operations will be found in the following tables:

In Table No. 1 will be found analyses of cane chips sampled by the method just described, made as follows: The chips were boiled with about five times their weight of water for a time averaging one hour and a half. Fresh portions of water were added from time to time to keep the volume nearly constant. After cooling, the contents of the flask or dish were made up to a given volume or weight and subjected to examination.

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* I first used tubes constructed as above in 1881, but tried then paper pulp and films of filter-paper on the linen. I first used asbestos in the summer of 1883, and found it far superior to anything else.

The optical analyses were made by double polarization. The chemical analyses were made either by direct titration with Fehling's solution, or by the permanganate method already described. These several methods are designated in the tables by "optical," "copper," or "permanganate." Where the first has been used with either of the others, it is designated by "optical and reducing."

In each table the results of the analyses of the chips (or bagasses) are compared with the theoretical composition indicated by the analyses of the juices. In this calculation the sorghum-cane is taken at 89 per cent. juice, and 11 per cent. cellulose, &c.; the Louisiana cane at 92 per cent. juice, and 8 per cent. cellulose, &c. The percentage of juice to weight of cane expressed from the sorghum canes was nearly 65, and from the Louisiana cane nearly 67.

The theoretical composition of the bagasse was computed on the basis of these figures. In these compositions it is assumed that the composition of the juice expressed is similar to that remaining in the bagasse, a view which is not opposed by any well verified facts.

The table No. 2 contains the results of the analyses made as in the first, with the exception that the boiling was continued twice as long.

In Table No. 3 are found the data given by treating the chips with five successive portions of water (each portion somewhat greater than the volume of the chips). After each boiling the water was poured off and fresh portions added.

Table No. 4 differs from the preceding only in having the chips treated with ten portions of water instead of five. In some cases the chips were mashed in a mortar, but this process did not seem to increase the per cent. of sugar extracted.

Table No. 5 contains the results of treating the chips with alcohol instead of water. Both processes were employed with alcohol, *i. e.*, boiling with a given volume or with successive portions. The determinations with alcohol were made by single polarization—alcoholic solutions not lending themselves easily to inversion. The green coloring matter extracted by the alcohol is a serious objection to its use in extracting sugar from the chips.

Several experiments were also made to determine the sugar by exhausting the chips with alcohol in an extractor. Both fresh and dried chips were used. With dried chips the process is much more successful than with the fresh. The time employed in extraction varied from one hour to four days. The result of these experiments in varying the time is to show that little advantage accrues from extending the time of extraction beyond two hours. In nearly all cases the fresh chips were thoroughly bruised in a mortar with pure sand before being placed in the extraction tube. The mean percentage of sugar as determined by the extraction of the chips with alcohol was nearly 2 per cent. less than calculation from the composition of the juice indicated. The further prosecution of this method was therefore abandoned.

Table No. 6 contains results of analyses of chips heated for one hour at 100° C. in a closed bottle, with five times their weight of water.

In Table No. 7 the same as above, except that the heating was continued for two hours.

BAGASSES.

Table No. 8 contains analyses of bagasses from canes from which the mill *juice* given in the table was expressed. The theoretical composition of the bagasse was calculated as follows:

(1.) The total juice in the canes is taken at 89 per cent. of their weight for sorghum and 92 per cent. for sugar-cane.

(2.) The weight of the bagasses, except in the case of the Louisiana canes, was 36 per cent. that of the canes.

(3.) The total weight of *juice* remaining in the bagasse was therefore 36−11=25 per cent. of total weight of cane, *i. e.*, 100 kilograms cane contain 89 kilograms juice and 11 kilograms cellulose, &c., and 36 kilograms bagasse contain 25 kilograms juice and 11 kilograms cellulose, &c.

The juice marked No. 1 in table gave an analysis 10.38 per cent. sucrose and 2.41 per cent. of other sugars. In 25 kilograms juice, therefore, there will be $.1038 \times 25 = 2.595$ kilograms of sucrose and $.0241 \times 25 = .602$ kilograms of other sugars. Then $2.595 \div 36 =$ percentage sucrose in the bagasse $= 7.21$, and $.602 \div 36 =$ percentage other sugars in bagasse $= 1.67$.

In Table No. 9 the same conditions obtain as in No. 8, except that the boiling was continued twice as long.

Table No. 10 contains analyses of bagasses boiled with five successive portions of water. Each portion was somewhat larger in weight than the bagasse, and the boiling each time was prolonged ten to fifteen minutes.

Table No. 11, same as above, only ten extractions were made instead of five.

Table No. 12, bagasses heated in closed bottle one hour, with five times weight of water.

Table No. 13, same as above, heated for two hours.

TABLE No. I.—*Cane chips boiled with five times weight of water.*

Time, average, one hour and thirty minutes.

Number.	Character of sample	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10.38	2.41						
2	Chips	Copper	8.66	2.09	9.24	2.14	0.58		0.05	
3	do	Optical	8.33		9.24		0.91			
4	do	do	8.43		9.24		0.81			
5	do	do	7.78		9.24		1.46			
6	do	Copper	7.35	1.98	9.24	2.14	1.89		0.16	
7	do	do	7.29	2.14	9.24	2.14	1.95		0.00	
8	Juice	Optical and reducing	9.38	2.72						
9	Chips	Copper	7.07	2.24	8.35	2.42	1.28		0.18	
10	do	Permanganate	7.46	2.69	8.35	2.42	0.89			0.27
11	do	Optical	6.96		8.35		1.38			
12	Juice	Optical and reducing	9.69	2.43						
13	Chips	Optical	7.69		8.68	2.16	1.01			
14	do	do	7.66		8.68		1.02			
15	do	Permanganate	7.88	2.65	8.68	2.16	0.86			0.49
16	do	Copper	6.86	2.80	8.68	2.16	1.82			0.64
		Mean					1.22		0.10	0.35

TABLE No. II.—*Cane chips boiled with five times weight of water.*

Time, average, three hours.

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10.38	2.41						
2	Chips	Copper	8.07	2.17	9.24	2.14	1.17			0.03
3	do	Optical	7.79		9.24		1.45			
4	do	do	8.76		9.24		0.48			
5	do	do	7.86		9.24		1.38			
6	do	Copper	5.28	1.99	9.24	2.14	3.96		0.15	
7	do	do	6.87	2.17	9.24	2.14	2.37			0.03
8	Juice	Optical and reducing	9.38	2.72						
9	Chips	Copper	7.41	2.21	8.35	2.42	0.94		0.21	
10	do	Permanganate	6.25	2.68	8.35	2.42	2.10			0.26
11	do	Optical	7.34		8.35		1.01			
12	do	do	7.69		8.35		0.66			
13	Juice	Optical and reducing	9.69	2.43						
14	Chips	Optical	7.83		8.68	2.16	0.85			
15	do	do	7.49		8.68		1.19			
16	do	Permanganate	7.59	2.93	8.68	2.16	1.09			0.77
17	do	Copper	5.38	2.35	8.68	2.16	3.30			0.19
		Mean					1.92		0.18	0.26

Doubling the time of boiling appears to have no good effect on the results. The mean deficiency of sucrose is increased from 1.22 to 1.92 per cent.

TABLE No. III.—*Cane chips boiled with five successive portions of water, each portion a little greater than the volume of chips.*

Boiled twenty minutes each time.

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10.38	2.41						
2	Chips	Optical	8.79		9.24		0.45			
3	do	do	9.21		9.24		0.03			
4	do	do	8.41		9.24		0.83			
5	do	Copper	7.84	2.09	9.24	2.14	1.40		0.05	
6	do	do	6.73	2.05	9.24	2.14	2.51		0.09	
7	do	do	7.86	2.08	9.24	2.14	1.38		0.06	
8	do	do	7.02	2.05	9.24	2.14	2.22		0.09	
9	Juice	Optical and reducing	9.38	2.72						
10	Chips	Optical	7.10		8.35		1.25			
11	Juice	Optical and reducing	9.69	2.43						
12	Chips	Optical	7.69		8.68		0.99			
13	do	do	6.80		8.68		1.88			
		Mean					1.29		0.07	

This method does not secure better results than the preceding ones.

TABLE No. IV.—*Cane chips boiled with ten successive portions of water, each portion a little greater than the volume of chips.*

Boiled ten minutes each time.

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10.28	2.41						
2	Chips	Optical	8.36		9.24		0.88			
3	do	do	7.89		9.24		1.35			
4	Juice	Optical and reducing	9.38	2.72						
5	Chips	Optical	7.66		8.35		0.69			
6	Juice	Optical and reducing	9.69	2.43						
7	Chips	Optical	7.61		8.68		1.07			
8	do	do	7.76		8.68		0.92			
		Mean					0.98			

In this series of analyses no determinations were made of reducing sugars. The mean deficiency of sucrose is considerably less than by the preceding methods.

TABLE NO. V.—*Cane chips exhausted with alcohol.*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Remarks.
1	Juice	Optical and reducing	10.38	2.41				
2	Chips	Optical	7.80		9.24		1.44	Boiled with five successive portions of alcohol.
3	do	do	7.50		9.24		1.74	
4	do	do	8.10		9.24		1.14	Boiled with ten successive portions of alcohol.
5	do	do	6.87		9.24		2.37	
6	do	do	7.50		9.24		1.74	Boiled with five times volume of alcohol for one hour.
7	do	do	7.70		9.24		1.54	
		Mean					1.66	

The results given by treatment with alcohol are not encouraging. The green color of the extract makes accurate polarizations difficult. Animal char does not readily discharge the green color.

TABLE NO. VI.—*Heated in closed bottle for one hour at* 100° C *with five times weight of water*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	9.75	2.33						
2	Chips	Optical	8.67		8.68		0.01			
3	do	do	8.73		8.68			0.05		
4	do	do	9.33		8.68			0.65		
5	do	do	8.98		8.68			0.30		
6	do	Permanganate	8.34	1.96	8.68	2.07	0.34		0.11	
7	do	Copper	8.21	1.94	8.68	2.07	0.47		0.13	
8	Juice	Optical and reducing	8.79	2.09						
9	Chips	Optical	7.66		7.82		0.16			
10	do	do	8.14		7.82			0.32		
11	do	Copper	7.29	1.79	7.82	1.86	0.53		0.09	
12	do	Permanganate	8.81	1.93	7.82	1.86		0.99		0.07
13	Juice	Optical and reducing	11.95	2.50						
14	Chips	Optical	11.52		10.64			0.88		
15	do	do	11.43		10.64			0.79		
16	do	Permanganate	10.83	1.90		2.23		0.19	0.33	
		Mean					0.30	0.52	0.16	

The results of this method are extremely satisfactory for both sucrose and reducing sugar. In five cases the mean deficiency of sucrose was 0.30 per cent. In eight cases the mean excess of sucrose was 0.52 per cent. The results with the reducing sugars, as the table shows, are even better.

TABLE NO. VII.—*Cane chips heated in closed bottle for two hours with five times weight of water.*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in cane calculated from juice.	Per cent. of other sugars in cane calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	9.75	2.33						
2	Chips	Optical	8.76		8.68			0.08		
3	do	do	8.75		8.68			0.07		
4	do	do	9.34		8.68			0.66		
5	do	do	9.34		8.68			0.66		
6	do	Copper	8.39	1.92	8.68	2.07	0.29		0.15	
7	Juice	Optical and reducing	8.79	2.09						
8	Chips	Optical	8.05		7.82			0.23		
9	do	do	7.99		7.82			0.17		
10	do	Copper	6.16	2.08	7.82	1.86	1.66			0.22
11	do	Permanganate	8.68	1.70	7.82	1.86		0.86	0.16	
12	Juice	Optical and reducing	11.95	2.50						
13	Chips	Optical	12.02		10.64			1.38		
14	do	do	12.26		10.64			1.62		
15	do	Permanganate	11.81	1.97	10.64	2.23		1.17	0.26	
		Mean					0.97	0.69	0.19	0.22

While the results in this table are satisfactory, it does not appear that heating the sample for more than an hour is of any use.

TABLE NO. VIII.—*Bagasse boiled with five times weight of water.*

Average time, one hour and thirty minutes.

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10.38	2.41						
2	Bagasse	Permanganate	6.03	2.02	7.21	1.67	1.18			0.35
3	Juice	Optical and reducing	9.38	2.72						
4	Bagasse	Optical	6.09		6.51	1.89	0.42			
5	do	do	5.83		6.51		0.68			
6	do	Copper	6.00	1.97	6.51	1.89	0.51			0.08
7	do	Permanganate	5.60	2.18	6.51	1.89	0.91			0.29
8	Juice	Optical and reducing	9.69	2.43						
9	Bagasse	Copper	5.03	1.95	6.73	1.69	1.70			0.26
10	do	Permanganate	4.10	2.00	6.73	1.69	2.63			0.31
11	do	Optical	5.38		6.73		1.35			
12	do	do	5.03		6.73		1.70			
		Mean					1.23			0.26

The method is unsatisfactory. The results show either inversion of cane sugar in boiling the bagasse with water, or that in crushing a larger percentage of sucrose than of other sugars is expressed.

TABLE No. IX.—*Bagasse boiled with five times weight of water.*

Average time, three hours.

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10. 38	2. 41	......	......	......	......	......	......
2	Bagasse	Permanganate	5. 41	1. 58	7. 21	1. 67	1. 80	......	......	0. 18
3	Juice	Optical and reducing	9. 38	2. 72	......	......	......	......	......	......
4	Bagasse	Optical	5. 87	......	6. 51	......	0. 64	......	......	......
5	do	do	5. 90	......	6. 51	......	0. 61	......	......	......
6	do	Copper	5. 43	2. 04	6. 51	1. 89	1. 08	......	......	0. 15
7	do	Permanganate	5. 43	2. 30	6. 51	1. 89	1. 08	......	......	0. 41
8	Juice	Optical and reducing	9. 69	2. 43	......	......	......	......	......	......
9	Bagasse	Copper	6. 18	1. 97	6. 73	1. 69	0. 55	......	......	0. 28
10	do	Permanganate	5. 29	2. 01	6. 73	1. 69	1. 44	......	......	0. 32
11	do	Optical	5. 01	......	6. 73	......	1. 72	......	......	......
12	do	do	6. 30	......	6. 73	......	0. 43	......	......	......
		Mean	......	......	......	......	1. 04	......	......	0. 27

This table is additional evidence of the truth of the statement made at the end of the preceding one.

TABLE No. X.—*Bagasse boiled with five successive portions of water.*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	10. 38	2. 41	......	......	......	......	......	......
2	Bagasse	Permanganate	6. 37	1. 84	7. 21	1. 67	0. 84	......	......	0. 17
3	Juice	Optical and reducing	9. 38	2. 72	......	......	......	......	......	....
4	Bagasse	Optical	6. 22	......	6. 51	......	0. 29	......	......	......
5	do	do	5. 10	......	6. 51	......	1. 41	......	......	......
6	Juice	Optical and reducing	9. 69	2. 43	......	......		......	......	......
7	Bagasse	Optical	2. 49	....	6. 73	......	4. 24	......	......	......
8	do	do	5. 79	......	6. 73	......	0. 94	......	...	......
		Mean	....	......	......	......	1. 54	....	......	0. 17

This method gives results similar to the two preceding ones.

TABLE NO. XI.—*Bagasse boiled with ten successive portions of water.*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	9.38	2.72	......	......	......	......	......	......
2	Bagasse	Optical	6.22	......	6.51	......	0.29	......	......	......
3	....do	do	5.48	......	6.51	......	1.03	......	......	......
4	Juice	Optical and reducing	9.69	2.43	......	......	......	......	......	......
5	Bagasse	Optical	3.20	......	6.73	......	3.53	......	......	......
6	....do	....do	6.11	......	6.73	......	0.62	......	......	......
		Mean	......	......	......	......	1.37	......	......	......

No marked advantage seems to accrue from increasing the number of extractions above five.

TABLE NO. XII.—*Bagasse heated in closed bottle at 100° C. for one hour with five times its weight of water.*

Number.	Character of sample.	Method of analysis.	Per cent. of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	9.75	2.33	......	......	......	......	......	......
2	Bagasse	Copper	7.16	2.07	6.77	1.62	......	0.61	......	0.45
3	....do	Optical	6.50	......	6.77	......	0.27	......	......	......
4	....do	....do	6.29	......	6.77	......	0.48	......	......	......
5	....do	....do	6.84	......	6.77	......	......	0.15	......	......
6	....do	....do	6.57	......	6.77	......	0.20	......	......	......
7	Juice	Optical and reducing	8.79	2.09	......	......	......	......	......	......
8	Bagasse	Permanganate	5.79	2.14	6.10	1.45	0.31	......	......	0.69
9	....do	Copper	6.13	1.87	6.10	1.45	......	0.03	......	0.42
10	....do	Optical	5.66	......	6.10	......	0.44	......	......	......
*11	Juice	Optical and reducing	11.95	2.50	......	......	......	......	......	......
12	Bagasse	Permanganate	8.54	1.71	8.08	1.82	......	0.46	0.11	......
13	....do	Optical	7.74	......	8.08	......	0.34	......	......	......
14	....do	....do	8.20	......	8.08	......	......	0.12	......	......
		Mean	......	......	......	......	0.34	0.27	0.11	0.52

* Louisiana cane.

This method, as with the cane chips, gives results which are entirely satisfactory.

TABLE No. XIII.—*Bagasse heated in closed bottle for two hours with five times its weight of water.*

Number.	Character of sample.	Method of analysis.	Per cent of sucrose.	Per cent. of other sugars.	Per cent. of sucrose in bagasse calculated from juice.	Per cent. of other sugars in bagasse calculated from juice.	Deficiency of sucrose, per cent.	Excess of sucrose, per cent.	Deficiency of other sugars, per cent.	Excess of other sugars, per cent.
1	Juice	Optical and reducing	9.75	2.33	......	......	......	......	......	......
2	Bagasse	Optical	5.95	......	6.77	......	0.82	......	......	......
3	do	do	6.05	......	6.77	......	0.72	......	......	......
4	do	do	6.23	......	6.77	......	0.54	......	......	......
5	do	do	6.17	......	6.77	......	0.60	......	......	......
6	Juice	Optical and reducing	8.79	2.09	......	......	......	......	......	......
7	Bagasse	Permanganate	6.16	2.05	6.10	1.45	......	0.06	......	0.60
8	do	Copper	5.93	1.84	6.10	1.45	0.17	......	......	0.39
9	do	Optical	5.95	......	6.10	......	0.15	......	......	......
10	do	do	5.60	......	6.10	......	0.50	......	......	......
*11	Juice	Optical and reducing	11.95	2.50	......	......	......	......	......	......
12	Bagasse	Permanganate	8.45	1.74	8.08	1.82	......	0.37	0.08	......
13	do	Optical	6.71	......	8.08	......	1.37	......	......	......
14	do	do	8.55	......	8.08	......	......	0.47	......	......
		Mean	......	......	......	......	0.61	0.30	0.08	0.49

*Louisiana cane.

No advantage is obtained by prolonging the boiling to two hours.

ANALYSIS OF CANES AND BAGASSES IN CLOSED BOTTLES.

This method of analysis is the only one of the various procedures tried that gives results as near theory as the difficulty of sampling will allow. It is, therefore, worthy of a detailed description.

THE APPARATUS.

For polariscopes like the Laurent shadow instrument, taking 16.19 gms. sucrose, volume 100 c. c., for a normal charge, the bottle should hold about 300 c. c. It should be strong, of well-annealed glass, and furnished with a patent rubber stopper, such as is commonly used on beer bottles.

The bottle should have a long neck, plainly marked at 305.4 c.c. This bottle should be of such a size that this mark will fall at the junction of the lower third of the neck with the upper two-thirds. It is perfectly safe to assume that the volume occupied by the cellulose and insoluble parts of the chips is equal to a volume of water of the same weight. It is also safe to assume, for sorghum canes in general, that the cellulose amounts to 11 per cent. of the total weight of the cane, and, in tropical cane, to 8 or 9 per cent.

For sorghum canes, therefore, the volume occupied by the cellulose of 16.19×3 grams of cane chips would be 5.4 c. c. ($16.19 \times 3 \times 11 = 5.4$ nearly).

The total volume, therefore, should be 305.4 in order to make the mixture normal for the polariscope. It is best, however, to have the neck of the extraction bottle marked with other volumes, *e. g.*, at 304.4 c. c. for Southern sugar cane.

The weight of cellulose in 16.1 gms., fresh sorghum-cane chips, is 1.772 gms. This weight of perfectly exhausted cane pulp was put into each of five flasks with the normal weight of sugar (16.19 gms.), and the volume made up to 100 c. c.

The sugar solution was then filtered and polarized, and compared with a solution of sugar of the same volume to which no pulp had been added. The following are the results of the experiments:

No.	Description.	Polarization.	Theory with pulp.	Variation.
		Per cent.	*Per cent.*	*Per cent.*
1	Sugar without pulp	98.5	......	
2	With pulp	101.0	100.25	+.75
3	do	101.0	100.25	+.75
4	do	100.0	100.25	—.25
5	do	101.0	100.25	+.75
6	do	100.0	100.25	—.25

Perhaps a greater number of determinations should be made before assigning a definite number to the influence of the cellulose. The results of the table, however, show that practically the correction assumed is of the proper magnitude.

THE MANIPULATION.

The chief care should be given to taking the sample. As large a quantity as is convenient of the canes (or bagasses) should be passed through the cutter and chopped as fine as possible. The chopped mass is then thoroughly mixed and the sample taken. After weighing the chips are transferred to the bottle, the vessel in which they were weighed rinsed with water, and the washings poured into the bottle. This is then filled to the mark, closed, and placed in cold water, which is rapidly heated to ebullition. After an hour the bottle is removed, cooled slowly (do not put at once into cold water), and the solution filtered for polarization or reduction. (Before filling with water a few c. c. of basic acetate of lead should be added; or the bottle may not be filled quite to the mark, and after cooling lead acetate is added and the volume made up to the standard.)

By having a large number of bottles many analyses can be carried on at once. Since an even sample is so hard to get it is always advisable to make the analyses in duplicate or triplicate and take the mean of the results.

USE OF SULPHUR.

The use of sulphurous dioxide (sulphur fumes) in sugar work has a threefold purpose. (1.) It assists in defecation. (2.) It bleaches the coloring matters of the juice. (3.) It prevents fermentation.

I have already alluded to the use of sulphur as lime bisulphite, and will confine this section to a discussion of the application of sulphurous dioxide directly to the juice.

MANUFACTURE OF SULPHUROUS DIOXIDE (SO_2).

(1.) The simplest method of manufacturing this article is by burning sulphur. This should be done in furnaces made of fire-brick, since hot iron is readily attacked by sulphur.

(2.) Sulphurous dioxide is also readily formed by heating charcoal with strong sulphurous acid (oil of vitriol).

(3.) It may also be made by treating some sulphite or bisulphite (as lime, &c.) with a stronger acid, *e. g.*, oil of vitriol.

The sulphurous acid used in sugar or sirup making is manufactured in one of the three ways mentioned.

PROPERTIES.

Sulphurous dioxide (or acid) is a colorless gas, more than twice as heavy as air. Its odor is familiar in the fumes of a burning sulphur match. The gas is very soluble in water, 1 volume of the latter absorbing about 40 volumes of the gas at ordinary temperature. One litre of water, therefore, will absorb nearly 115 grams of the gas, or one gallon of water at 60° F. saturated with the gas will contain of it a little more than 10 ounces.

In aqueous solution sulphurous acid (it becomes an acid by solution in water) easily undergoes oxidation, and its bleaching power is due to this process, by which nascent hydrogen is set free, which attacks the coloring matter. An equivalent amount of sulphuric acid is always formed. It is therefore advisable to use lime (or some base which will form an insoluble compound) with sulphurous acid in order to form a precipitate with the sulphuric acid which is produced.

Sulphurous dioxide, by a freezing mixture (as ice and salt), or by pressure, is easily condensed to a colorless liquid which is about one-half heavier than water. This liquid boils at a temperature of 8° C. below zero. I would suggest that it might prove profitable both to sugar manufacturer and chemist to prepare this liquid oxide at a central factory and ship it in suitable iron vessels to the sugar works. In this way the sugar-maker could always have at hand and under complete control a pure article of sulphurous dioxide.

The antiseptic properties of this body are even more marked than its bleaching powers. In a substance so prone to fermentation as cane and beet juice such a preserving agent is of the utmost importance. Dilute cane juices saturated with the gas or a bisulphite may be kept for days and even years unfermented.

APPLICATION.

The gas may be applied directly to the juice—

(1.) By conducting it into the vessel containing the juice and allowing it to be absorbed.

The juice should be cold, and the tube delivering the gas (lead or copper) end in an expanded nozzle covered with a plate of fine holes.

In some cases the tank is furnished with a copper coil perforated with small holes. A more even distribution of the gas throughout the liquid is thus obtained.

If the gas is formed by burning sulphur it is pumped first through a wash-bottle and then into the tank.

(2.) The juice may be mixed with the gas in a sulphur box.

The sulphur box may be used in two ways.

(*a*) A tight box (Fig. 9) is constructed of a size proportionate to the quantity of juices to be sulphurized. For a mill grinding 25 tons of cane per day the box should be 8 feet high and 3 feet square. Shelves with fine perforations are attached alternately to opposite sides of the box. They are set so as to facilitate the flow of the liquid

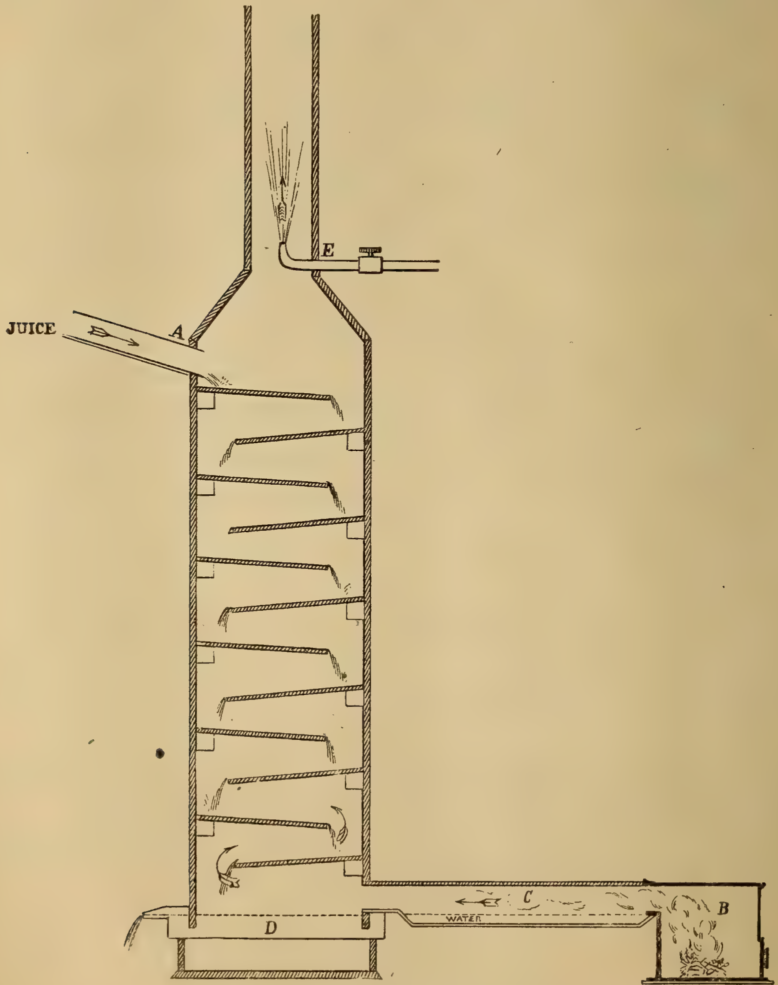
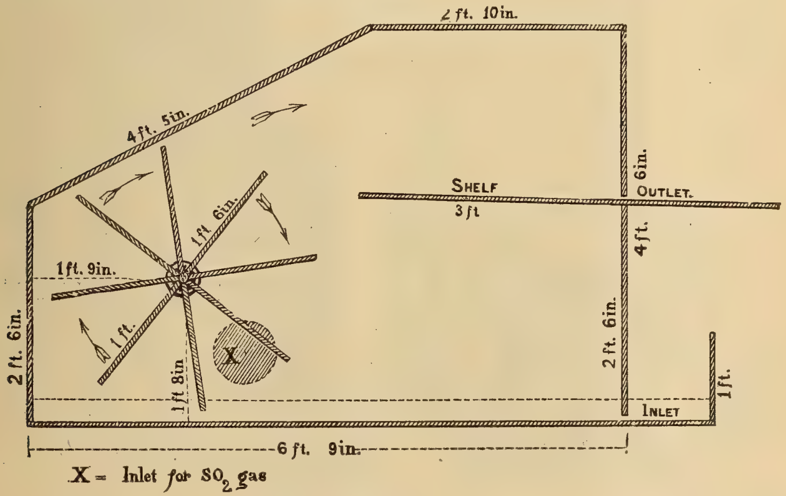


FIG. 9.

towards their free edges. The perforations should be sufficiently numerous to allow nearly the whole volume of juice to pass through each shelf in drops or spray. The sulphur is burned in the furnace (*B*), passes through a horizontal flue (*C*) in the bottom of which is water for the purpose of absorbing any sulphuric acid that may be formed during the combustion.* The sulphur fumes enter the box and pass back and forth upward through the box. At (*C*), a steam pipe is inserted in the flue so that additional draft may be secured. If the flue, however, be made high, little use for the steam jet will be found. The juice comes from the mill through the pipe (*A*.) If the mill be on the same line with the sulphur box a pump should be attached to it to elevate the juice to the proper altitude. This method of sulphurizing is simple and economical, and, if care be given to the furnace to secure a regular combustion of the sulphur, reasonably satisfactory.

(*b*) A better method of mixing the gas with the juice is found in the mechanism represented in Fig. 10. The figure represents a section through the center of the sulphur box.



CROSS SECTION.
FIG. 10.

The sulphur fumes enter through the opening (*X*) in the side of the box. A flue from the furnace where the sulphur is burned fits into the opening. The paddle-wheels turn in the direction of the arrows and with a velocity sufficient to throw into spray the juice entering the inlet and project it on to the shelf, whence it passes through the outlet to a juice tank. The paddle-wheel is so adjusted that there is always enough juice in the box to seal the inlet and thus prevent the air from entering. The box should be as nearly as possible air-tight. The suction produced by the paddles makes a sufficient draft for the furnace. The proper speed of revolution of the wheel is one hundred and fifty to three hundred per minute. The box is used by Mr. E. W. Deming, of Lafayette Sugar Works. I am indebted to him for many courtesies received during the preparation of this report.

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* For sirup making this is not necessary.

APPARATUS FOR MAKING SULPHUROUS ACID OR LIME BISULPHITE FOR SMALL PLANTS.

In working sorghum for sirup the use of sulphurous acid or lime bisulphite produces an article of superior merchantable properties. I will therefore give an account of an apparatus for the home manufacture of these articles. I append a description and cut of the apparatus.

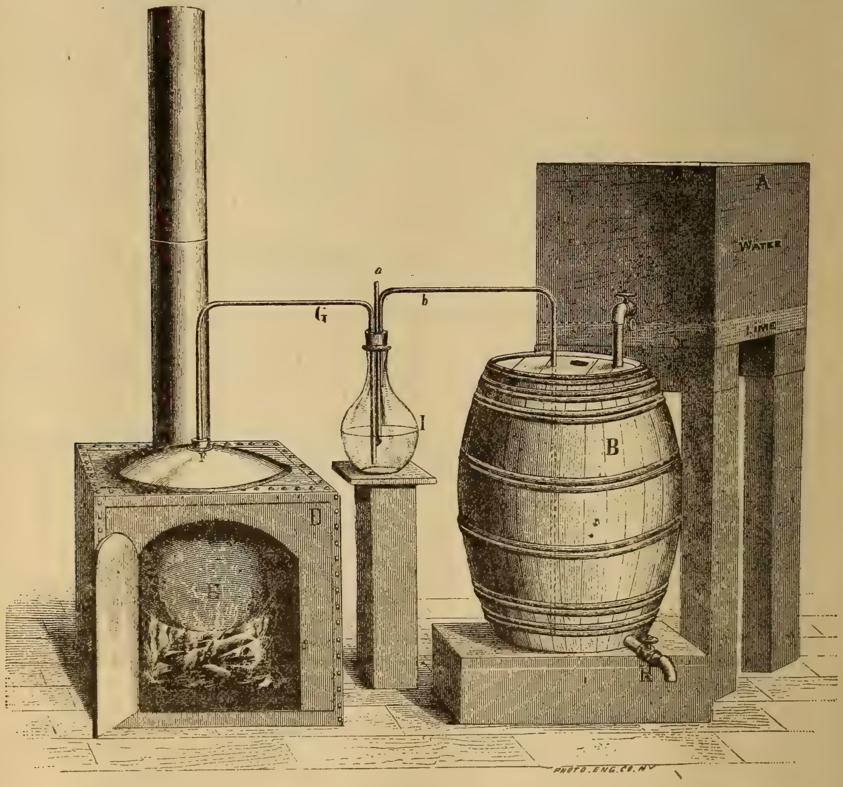

FIG. 11.

I am indebted to Mr. W. L. Anderson for the following account of the apparatus and its history:

(A) (Fig. 11).—Tank holding double the quantity of barrel (B). In this is placed a bushel of unslaked lime. The tank is then filled with water and the lime well stirred up and allowed to settle, when clear the water is ready to be drawn off. Fresh lime should occasionally be added to that in the tank so that the hydrate may be of a uniform strength. It is best to add a little each time the tank is filled with water.

(B).—Barrel for forming the bisulphite. This is filled from the tank by opening the globe-valve on pipe (C), which enters the tank above the settled lime. After the barrel is almost filled add about 2 gallons of weak milk of lime. This barrel, as well as all others used for bisulphite, should be of hard wood.

(D).—Furnace so made as to fit snugly around kettle (E.) It has a sheet-iron door, and a chimney. The kettle is hung by rods run through the ears and laid obliquely across the corners of the furnace.

(F).—A jug so shaped as to fit the kettle, holding about 5 gallons. Under and around the jug is sand to prevent it from heating or cooling too suddenly. The jug should be heavily glazed inside. It is charged with about 2 gallons of charcoal and the same quantity of strong sulphuric acid. This will make 2 barrels of bisulphite, and start another, perhaps finish it. Before charging the jug again ascertain if the coal in the jug is dry; if so, put in more sulphuric acid and less coal than you did before. When the residue gets too great take out the jug and clean it.

(G).—Copper pipe, three-quarter inch in diameter, used to convey the gas from the jug to the barrel. A rubber stopper, fitting the mouth of the jug is screwed on the end of the pipe entering the jug. The other end reaches almost to the bottom of the barrel. If gas leaks about the rubber stopper keep it down with weights, and put dough around the leak. It will take from six to eight hours to finish a barrel. As soon as you perceive a pungent odor escaping from the barrel cover the openings. You should have an opening through which you can stir the liquid occasionally.

(H).—Outlet made of two pieces of pipe and a globe-valve.

This apparatus cost us $10.75. The sulphuric acid, coal, lime, and wood cost about 50 cents per barrel of bisulphite. The labor required in manufacturing is but trifling.

If you wish to make sulphurous acid, charge the barrel with pure water and proceed as in making bisulphite. A "wash bottle" (*G*) can be used between the jug and barrel (B). This will improve the product.

In the year 1860 we bought 6 gallons of bisulphite of lime, as an experiment, paying 50 cents per gallon. From that time to the present we have made no sirup without it. We paid $11 per barrel and freight, which made it almost $13, for all we used from 1861 to 1873.

In using our bisulphite we put it into the cold juice just before the tank is full The old rule was, "a quart to 50 gallons of juice." But there is no invariable rule. The quality of the bisulphite, the quality of the juice, and the amount of lime used, will vary the amount.

I have made a few changes in the sketch of the apparatus as furnished by Mr. Anderson.

Instead of using a stone jug as a generator, it would be better to employ one made of cast iron. Strong sulphuric acid, even when hot, acts very slowly on iron. Care must be exercised, however, to avoid using the dilute acid, which would rapidly dissolve the iron.

Instead of copper pipes lead or glass may be used. The wash-bottle should be of strong glass, and of at least 2 gallons capacity. It should be filled with water to the mark indicated in the drawing. The stopper should have three perforations, one to carry the tube (G). This tube should extend to near the bottom of the bottle.

The second hole is for the tube (*b*), which should begin about 2 inches below the stopper and extend nearly to the bottom of the barrel (B.) The third aperture carries the safety tube (*a*), which ends about an inch below the liquid in the wash-bottle. This tube prevents any regurgitations from the barrel into the generator. The heat should be applied slowly, and regulated by watching the flow of gas through the wash-bottle.*

HARVESTING CANE.

In the sugar industry every device that promises to serve true economy is worthy of close attention. One of the best methods of harvest ing cane, in my opinion, aside from the use of the tramway, is that practised by Mr. E. W. Deming, superintendent of the sirup works at West Point, Ind.

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*A gasoline stove would be better than a furnace for heating the generator. Care should be taken not to raise the temperature above the point necessary for gradual evolution of the gas.

Following is his description of the method of harvesting, taken from the Rural World, of Saint Louis :

"Stripping costs from one and one-half to three dollars per acre. Cane with leaves on loads easier, rides without slipping, dumps better, men at the mill prefer to handle it, and it feeds better at the mill. Some claim the leaves fill in between the stalks as it passes through the mill, giving a higher per cent. of juice. Some claim cannot pass as many stalks through the mill in a given time as with stripped cane, but this surely will not compensate for the expense of stripping and inconvenience in handling. Cane is handled on platform wagons made expressly for that purpose. The forward wheels average 34 inches in diameter, 3 inches tire, and 3-foot tread. The rear wheels average 38 inches in diameter, 4-inch tire, and 5-foot tread. Platform 12 feet long, 5½ feet wide, evenly balanced on rear axle. The wheels are entirely under the platform. A good team with these wagons will haul a ton on soft ground, where a lumber wagon would cut down 8 inches. The cutter with his left arm bends over a few stalks of the outside row, cutting them so they fall directly from the rows; following him is a man who grasps the fallen stalks just below the tuft, until he has all he can clasp with one hand then, taking one step directly from the cane, he drops the heads in a bunch, the buts being spread out fan-shaped. Cane is cut in lands, same as plowing. If cane stands up well, one cutter will keep two men picking up; if down or tangled, one man will pick it up. As the cane wagon follows, the driver grasps with one hand the stalks of cane just below the tuft and raises the armful with the other, throwing it on the wagon with the heads projecting over as far as you wish to top them. When the wagon is loaded the tops are all on one side and even. The wagon is then driven to some high, dry place, where you wish to deposit the seed, when the driver, with a heavy hay-knife, with a straight handle, cuts off the heads with a few blows. The wagon now goes to the foot of the carrier, where it is dumped in ten seconds and ready to return to the field. The cane is handled with no regard to the evenness of the butts, and would be a little inconvenient for hand-fed mills, especially if cane was unstripped. By this method the small canes or suckers are left on the ground. The seed is left in piles where it can be easily loaded on wagons with a fork, leaving no scattered seed for a volunteer crop."

THE POLARISCOPE.

The polariscope, or optical saccharometer, is an instrument designed to measure the quantity of sucrose in any sugar solution. It depends on the principle that a plane of polarized light passing through a tube containing a solution of sucrose is twisted toward the right (like the movement of the hands of a clock), and the degree of this rotation is proportionate to the amount of sugar in solution.

Two kinds of polariscope are in common use:

(1) Those which use ordinary light, like that of a lamp or the sun.

(2) Those which use light of one color (monochromatic light).

The first kind is more expensive and more convenient as regards the source of light; the second, cheaper and more accurate.

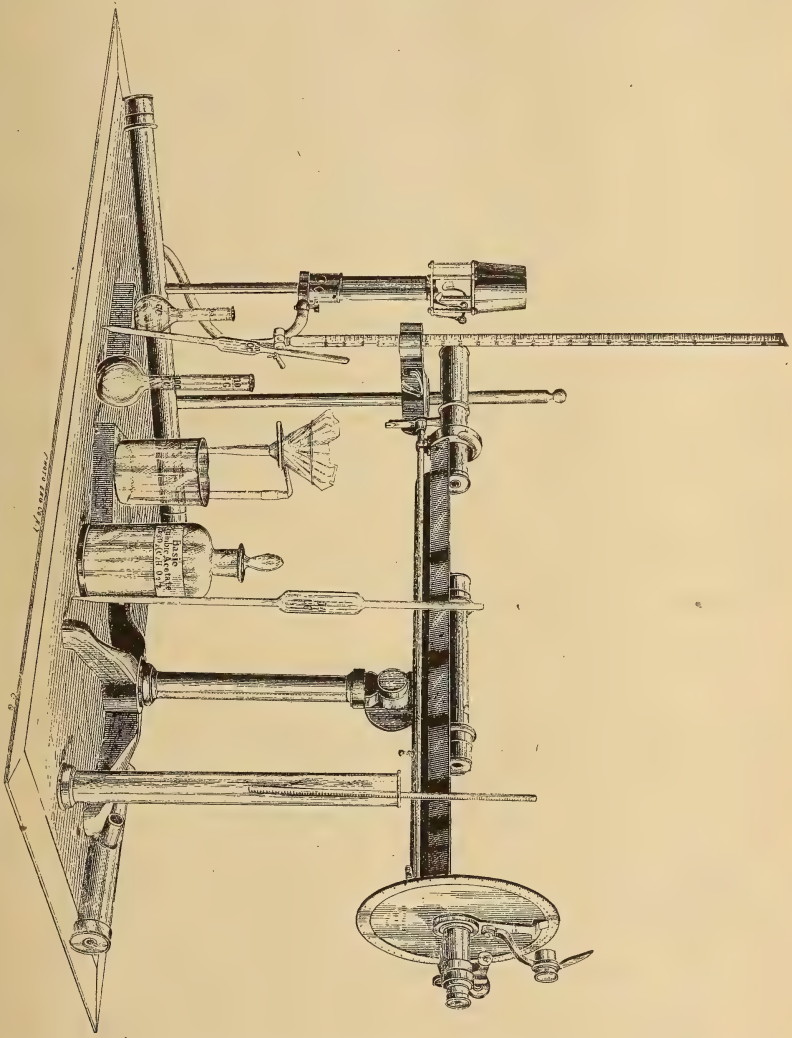

FIG. 12.—Polariscope and apparatus necessary for optical analysis.

The chief objection to the use of a polariscope in small sugar works is (*a*) the cost and (*b*) the absence of any one skilled in its use.

Polariscopes of the finest construction and large size cost several hundred dollars, while even those less carefully constructed and smaller in size cannot be had for much less than $100.

The figure (12) contains a view of the apparatus necessary for making an optical analysis of the juices of the cane.

The polariscope containing the apparatus for converting ordinary into polarized light; device for analyzing the polarized ray and the divided circle and vernier for measuring and reading the amount of rotation.

Lamp for furnishing monochromatic light (a gas lamp furnished with spoons of platinum which carry fragments of fused common salt).

Pipettes for measuring the sugar solution.

Hydrometer for determining specific gravity.

The specific gravity having been determined it is easy to calculate the weight of solution taken from the volume measured in the burette. Thus if 10 cubic centimeters be measured the specific gravity of which is 1.06, the total weight of the juice taken is $1.06 \times 10 = 10.6$ grams.

The instrument figured in the cut is so adjusted that 16.19 grams of pure sugar dissolved and made up to 100 cubic centimeters will read 100 on the scale. A fifteen cubic centimeter pipette should be used for ordinary cane juices. This volume (15 cubic centimeters) will weigh so nearly 16.19 grams that the difference may be neglected.

By using a pipette in this way or a burette, no balance is required, and thus a very expensive piece of apparatus is dispensed with.

Burette for the more exact measurement of juice.

Basic acetate of lead. This chemical is prepared by taking ordinary sugar of lead and boiling a strong solution of it for some time with an excess of litharge (oxide of lead). The solution is then filtered and must be kept in a well-stoppered bottle.

Funnels, filter-stands, and filter-papers.

Flasks, graduated for making solutions up to standard volume.

THE PROCESS.

Measure out as nearly as possible 16.2 grams (or two or three times that amount) into the 100 cubic centimeter flask.

Add two or three cubic centimeters of the basic acetate of lead solution, and then fill up to the mark with pure water.

Shake the flask well, holding the ball of the thumb on its mouth, and filter into the tube of observation. When the tube is full, put on the cap and place in the polariscope. Having adjusted the light, turn the instrument until both halves of the field of vision are of the same tint. In the monochromatic instrument, before adjustment one-half of the field of vision will appear dark and the other yellow.

The disk is now turned until both halves are equally illuminated. In the other instrument one-half the field of vision will be blue and the other rose-red. The adjustment is now made until both halves appear alike.

Through the small microscope which is focused on the vernier is now read off the number of divisions through which the analyzer has been turned. This number is the percentage of sugar if 16.2 gms. of the original juice have been taken. Otherwise it is to be divided by the number of times that weight used. (In some instruments other weights are normal, *e. g.*, 26.048 gms. With each instrument will be found instructions giving the weight of sugar to which the scale is graduated.)

A good deal of practice is necessary to use the polariscope accurately and quickly, but I do not see why any person endowed with ordinary ingenuity may not determine the percentage of sucrose in cane juices with a reasonable degree of accuracy by means of the polariscope.

More accurate analyses, as well as analyses of sirup and meladas, must be left in the hands of the chemist.

The flasks, burettes, funnels, &c., necessary to the analyses of cane juices (excluding the polariscope), ought not to cost more than $10.

The intending purchaser should get: 3 pipettes 5, 10, and 15 c. c. capacity; 6 sugar flasks, marked on neck at 100, and 110 c. c.; 2 burettes; 6 funnels; 2 quires filter paper; 2 hydrometers. The other apparatus he can easily improvise.

This apparatus can be had of any dealer in chemical supplies.

TRANNIN'S POLARISCOPE.

The high price of the ordinary polariscope, the delicacy of its adjustment, and the skill required in its use, have made it desirable that

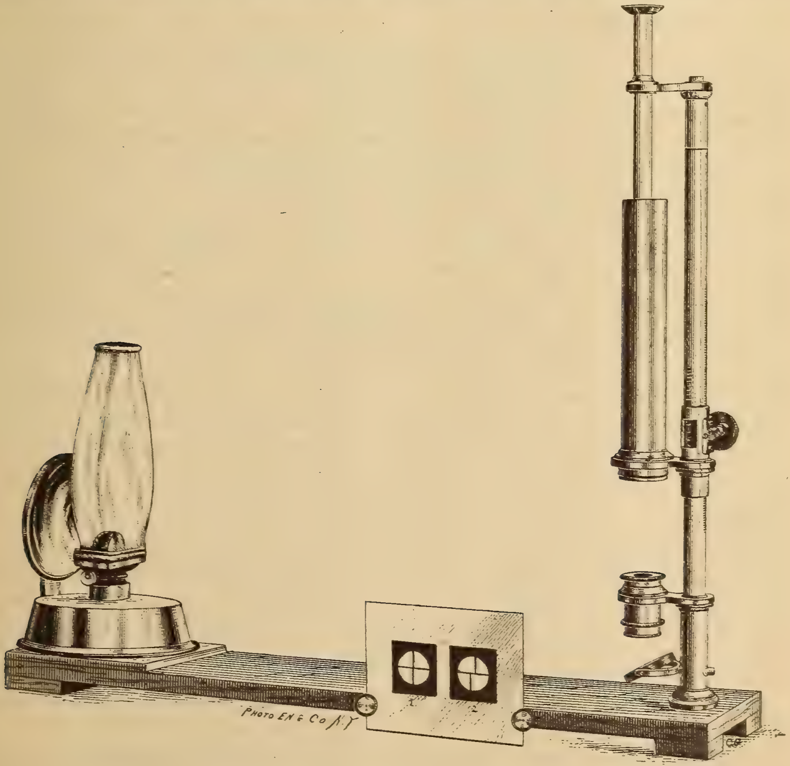
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FIG. 13.—Trannin's polariscope.

a more simple and a cheaper instrument should be devised for general use.

Mr. Trannin, a French sugar chemist, has attempted this, and has invented an apparatus which in simplicity leaves nothing to be desired.

Fig. 13 shows this instrument. (2) Fig. 13 shows the appearance of the field of vision when the tube (*t*), which holds the sugar solution, is empty or not adjusted. (1) Fig. 13 represents the same when the sugar solution is in the tube, and the adjustment made, ready for reading. No particular skill is required in the use of this instrument, and I have found that successive readings do not differ by more than one-half of one per cent.

It promises therefore to be of great use to manufacturers.

I append Mr. Trannin's description of his invention.

SACCHARIMÉTRE DES RAPERIES.*

Impressed for a long time with the incomplete and often deceitful ideas which the use of the densimeter alone gives, I have sought whether it might not be possible to devise a more rapid method of analysis of the juice (optically) and one more accessible to employés little skilled in polarimetry.

The large saccharimeters aside from their very high price, are really very difficult to manipulate. The large number of pieces of which they are composed, their arrangement, and extreme delicacy of adjustment, create many causes of error.

These instruments are touched with a sort of fear, and they are committed only to careful and skillful operators.

The problem of light for the saccharimeter is often a cause of ennui and difficulty. Now it is the monochromatic light which is required by the instrument, and with it, its mode of production so troublesome. Again it is the delicate appreciation of the shadows, or the chromatic equalization impossible to be obtained by eyes affected with daltonism. These difficulties are real, and indeed some manufacturers have been compelled to discontinue the use of the saccharimeters, not because these instruments were poor, but because their continual use was not practicable.

It was to avoid these inconveniences that I applied myself when I invented the little "Saccharimétre des raperies." Have I succeeded? Practical experience, on which I rely in all confidence, will answer.

First of all, I wished to do away with every kind of compensator, analyzing circle, and other movable optical pieces. The apparatus is thus reduced to three fundamental pieces, viz, the polarizer, the polariscope and the analyzer. These pieces are all fixed and therefore cannot be put out of order.

The light used may be either daylight or a gas or oil lamp. I have noticed, however, that the sensibility is greater with artificial than with daylight. The appreciation of the critical phenomenon, *i. e.*, of the phenomenon which is to be obtained when the reading is made, is particularly easy.

Two black bands are on the field of vision. These are to be brought exactly end to end and the reading is then made.

This phenomenon is so easy of observation that persons the least accustomed to making readings do not show the least hesitation in reproducing them.

Finally each one uses his usual means of vision. He who has normal sight does not need any aid. As to myopes and presbytes (long and short sight) they retain the glasses to which they are accustomed. The apparatus is therefore always ready for everybody.

The reading is made directly on a scale graduated into hundredths and half hundredths of sugar.

The apparatus is nickel-plated and consequently always clean and bright.†

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* Sucrerie indigène, vol. xxii, p. 329.

† Apparatus furnished by Queen & Co., Phiadelphia.

THE FUTURE.

I do not believe that the manufacture of sugar from sorghum, as at present carried on, will prove financially successful throughout the more northern portions of our country.

The process of manufacture is imperfect and wasteful. A large part of the sugar is left in the bagasse and another larger part passes into the molasses.

Not one-half of the sucrose in the juice is usually obtained as crystallized sugar.

The future success of the industry depends on the following conditions, viz:

(1.) A careful selection and improvement of the seed with a view of increasing the proportion of sucrose.

(2.) A definition of geographical limits of successful culture and manufacture.

(3.) A better method of purifying the juices.

(4.) A more complete separation of the sugar from the canes.

(5.) A more complete separation of the sugar from the molasses.

(6.) A systematic utilization of by-products.

(7.) A careful nutrition and improvement of the soil.

IMPROVEMENT BY SEED SELECTION.

I am fully convinced that the Government should undertake the experiments which have in view the increase of the ratio of sucrose to the other substances in the juice. These experiments, to be valuable, must continue under proper scientific direction for a number of years. The cost will be so great that a private citizen will hardly be willing to undertake the expense.

The history of the improvement in the sugar beet should be sufficient to encourage all similar efforts with sorghum.

The original forage beet, from which the sugar beet has been developed, contained only 5 or 6 per cent. of sucrose. The sugar beet now will average 10 per cent. of sucrose. It seems to me that a few years of careful selection may secure a similar improvement in sorghum.

It would be a long step toward the solution of the problem to secure a sorghum that would average, field with field, 12 per cent. sucrose and only 2 per cent. of other sugars, and with such cane the great difficulty would be to make sirup and not sugar. Those varieties and individuals of each variety of cane which show the best analytical results should be carefully selected for seed, and this selection continued until accidental variations become hereditary qualities in harmony with the well-known principles of descent.

If these experiments in selection could be made in different parts of the country, and especially by the various agricultural stations and colleges, they would have additional value and force. In a country whose soil and climate are as diversified as in this, results obtained in one locality are not always reliable for another.

If some unity of action could in this way be established among those engaged in agricultural research much time and labor would be saved and more valuable results be obtained.

IMPROVED DEFECATION.

In addition to experiments made with the ordinary methods of defecation during the past season, I have tried to apply the method in use with the beet juice in Europe.

These experiments were all made in a small way, but I think are of sufficient importance to the future of the industry to deserve brief mention here.

EXPERIMENTS IN DEFECATION.

The method consists essentially in first adding a large quantity of lime to the juice and afterwards removing it by the injection of carbonic acid.

The results of these experiments were most flattering. In many cases the coefficient of purity was considerably raised, and in all cases the defecated juice was limpid and clear, but of a reddish-yellow tinge. This coloration is due to a slight decomposing effect, which the lime, even in the cold, has on the anoptose, forming with it dark and bitter decomposition products. This deepening of color, however, does not affect the value of the process for sugar-making, although it would be an objection if sirup alone were the object of manufacture.

A few results will show the workings of the method.

No. (1).—A mill juice with a coefficient of purity of 61.60, after treatment as indicated above had this number raised to 69.12. In the same juice the percentage of albuminoids before defecation was 4.22,* and after defecation 3.42.*

No. (2).—A diffusion juice before treatment had a purity coefficient of 59.67, and after of 59.79. In the same juice the percentage of albuminoids before treatment was 4.06,* and after treatment 3.63.*

In most cases the treatment of the diffusion juices gave somewhat better results. In nearly all cases the relative amount of anoptose to sucrose was diminished, showing that a small portion of it was destroyed by the excess of lime.

In general I may say that this method of treatment succeeds better with mill than with diffusion juices, and for the obvious reason that the former have more impurities that can be removed by lime than the latter.

On account of the seeming importance of this method of purification to the future of the industry I will give a detailed account of the method of conducting it and of the analyses made in connection therewith.

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* Per 100 of sucrose.

BEET-SUGAR METHOD BY SINGLE AND DOUBLE CARBONATATION FOR THE DEFECATION OF SORGHUM JUICES.

This method consists essentially in adding an excess of lime to the juice, then removing the excess by a current of carbonic dioxide. In the method by double carbonatation a portion of the lime is first added in the cold and the excess removed, and then a second and smaller portion of lime is added, the juice being kept at the boiling point and the excess removed as before, the juice remaining neutral or slightly alkaline. The proportion of lime employed depends upon the character of the juice. A number of experiments has been made to determine that proportion which gives a good, clear, pure juice, easily filtered at a reasonable expense both of time and carbonic dioxide. A large number of results indicates that for diffusion juices 2 per cent. CaO, and for mill 3 per cent. CaO, are the best proportions.

Table No. 1 shows the influence of the lime in raising the coefficient of purity. The coefficient of purity of diffusion juice is never increased in proportion to that of the mill juice, as it contains much less of those substances acted upon by the lime. After the second carbonatation the results as to increase and decrease of coefficient of purity were not very satisfactory. The lime assumes a combination which prevents its being removed by the carbonic acid. This will be again referred to in discussing the results given under the table. The taste of the juice after the first carbonatation resembles that of the sap from the maple tree, but after the second it is bitter and unpalatable. The color was brownish, due to a slight decomposition of the anoptose. This coloration of the juice could be avoided on a large scale by rapid carbonatation. It is easily bleached by the use of bisulphite of lime or sulphurous acid.

Table No. 2 gives the proportion of anoptose to the sucrose before and after defecation. After the first defecation, *i. e.*, the defecation in the cold, the proportion of anoptose to the sucrose is reduced but little, though enough to indicate that it is the cause of the coloring of the juice. After the second carbonatation, hot, there is a very marked reduction in this proportion. The anoptose has evidently combined with the lime forming soluble and insoluble compounds; the soluble portion giving the deep brown coloration, which the juice acquires at the second defecation and the bitter unpleasant taste. Its remaining in solution also accounts for the total solids not decreasing in proportion to the amount of anoptose decomposed. The experiments made, show that the method by double carbonatation would not be a success, practically, with the sorghum juice, owing to the large amount of anoptose usually present in the juices of this cane. But the method by single carbonatation is very successful, inasmuch as the juice is not heated in contact with the lime.

Table No. 3.—It is seen from the analyses given in this table that the lime has a marked effect on the nitrogenous bodies present in the juice. After the first carbonatation about 33 per cent. of these substances have been removed.

A study of the tables will indicate the advantage which may be expected from the application of the lime and carbonic acid method of defecation to sorghum juices, with such modifications as the peculiar nature of these juices require.

If the experiment could be made on a large scale, I think the practical advantage of the process over any other now in use would be at once apparent.

TABLE I.—*Increase or decrease in coefficient of purity.*

BEFORE DEFECATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. sucrose.	Per cent. anoptose.	Per cent. total solids.	Specific gravity.	Per cent. ash.	Coefficient of purity, per cent.
Diffusion	1	......	4. 72	1. 40	6. 50	1. 0258	0. 279	72. 60
Do.	2	69	4. 76	1. 90	7. 80	1. 0309	0. 389	61. 02
Do.	3	85	5. 52	2. 32	8. 80	1. 0352	0. 400	62. 73
Do	4	96	5. 25	1. 38	8. 20	1. 0327	0. 578	64. 02
Do.	5	102	4. 02	1. 63	6. 80	1. 0270	(*)	59. 11
Mill	6	145	9. 64	3. 29	15. 50	1. 0633	(*)	62. 19
Diffusion	7	146	5. 83	1. 83	9. 20	1. 0369	(*)	63. 37
Mill	8	154	9. 21	3. 49	14. 95	1. 0611	(*)	61. 60
Diffusion	9	155	5. 46	2. 41	9. 15	1. 0366	(*)	59. 67
Mill	10	162	10. 69	3. 09	16. 82	1. 0692	(*)	63. 55
Diffusion	11	163	6. 81	2. 22	10. 95	1. 0441	(*)	62. 19

* Not determined.

AFTER FIRST CARBONATATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. sucrose.	Per cent. anoptose.	Per cent total solids.	Specific gravity.	Per cent. ash.	Coefficient of purity, per cent.	Per cent. Ca O.	Increase or decrease in coefficient of purity, per cent.
Diffusion	1	......	4. 92	1. 39	6. 90	1. 0274	0. 357	71. 30	3. 0	− 1. 30
Do.	1	......	4. 30	1. 51	7. 20	1. 0288	0. 322	59. 72	2. 0	−12. 88
Do.	1	.....	4. 23	1. 62	7. 60	1. 0302	0. 373	55. 65	1. 5	−16. 95
Do.	2	69	4. 92	1. 80	7. 35	1. 0292	0. 309	66. 93	2. 0	+ 5. 91
Do.	2	69	4. 91	1. 87	7. 70	1. 0307	0. 344	63. 76	1. 5	+ 2. 74
Do.	3	85	5. 20	2. 01	8. 10	1. 0323	0. 455	64. 19	3. 0	+ 1. 46
Do.	3	85	4. 83	1. 68	8. 10	1. 0320	0. 436	59. 62	2. 0	− 3. 11
Do.	3	85	5. 72	2. 26	9. 10	1. 0365	0. 423	63. 40	1. 0	+ 0. 67
Do	4	96	5. 39	1. 29	8. 00	1. 0318	(*)	67. 37	3. 0	+ 3. 35
Do.	4	96	5. 60	1. 42	8. 30	1. 0331	(*)	67. 47	2. 0	+ 3. 45
Do.	4	96	5. 92	1. 45	8. 90	1. 0355	(*)	66. 51	1. 0	+ 2. 49
Do.	5	102	4. 06	1. 03	7. 45	1. 0296	(*)	(?) 54. 49	2. 0	?− 4. 62
Mill	6	145	lost.	3. 91	14. 10	1. 0575	(*)	.....	2. 0	....
Diffusion	7	146	5. 79	1. 69	8. 60	1. 0343	(*)	67. 32	2. 0	+ 3. 95
Mill	8	154	11. 42	3. 31	16. 52	1. 0679	(*)	69. 12	3. 0	+ 7. 52
Diffusion	9	155	6. 47	2. 63	10. 82	1. 0435	(*)	59. 79	2. 0	+ 0. 12
Mill	10	162	10. 17	2. 75	14. 15	1. 0576	(*)	71. 87	3. 0	+ 8. 32
Diffusion	11	163	6. 75	1. 83	10. 50	1. 0423	(*)	64. 28	2. 0	+ 2. 09

* Not determined.

TABLE I.—*Increase or decrease in caefficieut of purity*—Continued.

AFTER SECOND CARBONATATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. sucrose.	Per cent. anoptose.	Per cent. total solids.	Specific gravity.	Coefficient of purity, per cent.	Per cent. Ca O.	Increase or decrease in coefficient of purity, per cent.
Diffusion	1	......	......	......	......	......	......	......	......
Do	2	69	......	......	......	......	......	......	......
Do	3	85	......	......	......	......	......	......	......
Do	4	96	......	......	......	......	......	......	......
Do	5	102	......	......	......	......	......	......	......
Mill	6	145	8. 90	1. 60	14. 22	1. 0579	62. 58	0. 5	+0. 39
Diffusion	7	146	5. 49	0. 69	8. 93	1. 0357	61. 47	0. 5	−1. 90
Mill	8	154	8. 71	1. 08	13. 80	1. 0562	63. 11	0. 5	−1. 51
Diffusion	9	155	6. 20	0. 93	11. 45	1. 0462	54. 14	0. 5	−5. 53
Mill	10	162	12. 05	1. 13	18. 60	1. 0769	64. 24	0. 5	+0. 69
Diffusion	11	163	6. 56	0. 58	11. 10	1. 0446	59. 09	0. 5	−3. 10

REMARKS.

Character of juice.	No. of experiment.	Serial number.	Remarks.
Diffusion	1	......	Did not heat to 90° C. as usual, to decompose the hydro-sucro-car-bonate of lime.
Do	1	......	
Do	1	......	
Do	2	69	Filtration easy.
Do	2	69	Do.
Do	3	85	Do.
Do	3	85	Do.
Do	3	85	Filtrate turbid.
Do	4	96	Filtrate easy.
Do	4	96	Do.
Do	4	96	Filtrate turbid.
Do	5	102	Did not heat to 90° C.
Mill	6	145	Filtration not easy.
Diffusion	7	146	Filtration easy.
Mill	8	154	Do.
Diffusion	9	155	Do.
Mill	10	162	Do.
Diffusion	11	163	

TABLE II.—*Increase or decrease in percentage of anoptose.*

BEFORE DEFECATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. ucrose.	Per cent. anoptose.	Anoptose per 100 of sucrose.
Diffusion	1	......	4. 72	1. 40	29. 66
Do	2	69	4. 76	1. 90	39. 91
Do	3	85	5. 52	2. 32	42. 02
Do	4	96	5. 25	1. 38	26. 28
Do	5	102	4. 02	1. 63	40. 54
Mill juice	6	145	9. 64	3. 29	34. 12
Diffusion	7	146	5. 83	1. 83	31. 38
Mill	8	154	9. 21	3. 49	37. 89
Diffusion	9	155	5. 46	2. 41	44. 14
Mill	10	162	10. 69	3. 09	28. 90
Diffusion	11	163	6. 81	2. 22	32. 59

TABLE II.—*Increase or decrease in percentage of anoptose*—Continued.

AFTER FIRST CARBONATATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. sucrose.	Per cent. anoptose.	Anoptose per 100 of sucrose.	Increase or decrease in percentage of anoptose.
Diffusion	1	....	4. 92	1. 39	28. 25	—1. 41
Do	1	....	4. 30	1. 51	35. 11	+5. 45
Do	1	....	4. 23	1. 62	38. 29	+8. 63
Do	2	69	4. 92	1. 80	36. 38	—3. 53
Do	2	69	4. 91	1. 87	38. 08	—1. 83
Do	3	85	5. 20	2. 01	38. 65	—3. 37
Do	3	85	4. 83	1. 68	34. 78	—7. 24
Do	3	85	5. 72	2. 26	39. 51	—2. 51
Do	4	96	5. 39	1. 29	23. 93	—2. 35
Do	4	96	5. 60	1. 42	25. 35	—0. 93
Do	4	96	5. 92	1. 45	24. 49	—1. 79
Do	5	102	4. 06	1. 03	25. 36	—15. 18 ?
Mill juice	6	145	Lost.	3. 91	....	....
Diffusion	7	146	5. 79	1. 69	29. 18	—2. 20
Mill	8	154	11. 42	3. 31	28. 98	—8. 91
Diffusion	9	155	6. 47	2. 63	40. 64	—3. 50
Mill	10	162	10. 17	2. 75	27. 04	—1. 86
Diffusion	11	163	6. 75	1. 83	27. 11	—5. 48

AFTER SECOND CARBONATATION.

Character of juice.	No. of experiment.	Serial number.	Per cent. sucrose.	Per cent. anoptose.	Anoptose per 100 of sucrose.	Increase or decrease in percentage of anoptose.
Diffusion	1	....	....	......	....	....
Do	2	69	....	......	....	....
Do	3	85	....	......	....	....
Do	4	96	....	......	....	....
Do	5	102	....	......	....	....
Mill juice	6	145	8. 90	1. 60	19. 03	—15. 09
Diffusion	7	146	5. 49	0. 69	12. 56	—18. 82
Mill	8	154	8. 71	1. 08	12. 39	—25. 50
Diffusion	9	155	6. 20	0. 93	15. 00	—29. 14
Mill	10	162	12. 05	1. 13	9. 37	—19. 53
Diffusion	11	163	6. 56	0. 58	8 84	—23. 75

REMARKS.

Character of juice.	No. of experiment.	Serial number.	Remarks.
Diffusion	1	....	Did not heat to 90° C. to decompose hydro-sucre-carbonate of lime; hence apparent increase in anoptose.
Do	5	102	Did not heat to 90° C.

TABLE III.—*Increase or decrease in percentage of albuminoids.*

BEFORE DEFECATION.

Character of juice.	Experimental number.	Serial number.	Per cent. sucrose.	Nitrogen per 100 of sucrose.	Albuminoids per 100 of sucrose.
Diffusion	3	85	5.52	0.413	2.581
Mill	6	145	9.64	0.370	2.314
Diffusion	7	146	5.83	0.813	5.081
Mill	8	154	9.21	0.675	4.218
Diffusion	9	155	5.46	0.650	4.062
Mill	10	162	10.69	0.353	2.206
Diffusion	11	163	6.81	0.691	4.322

AFTER FIRST CARBONATATION.

Character of juice.	Experimental number.	Serial number.	Per cent. sucrose.	Nitrogen per 100 of sucrose.	Increase or decrease in percentage of nitrogen.	Albuminoids per 100 of sucrose.	Increase or decrease in percentage of albuminoids.
Diffusion	3	85	5.20	0.315	—0.098	1.968	—0.613
Do	3	85	....	0.360	—0.053	2.251	—0.330
Do	3	85	....	0.375	—0.038	2.348	—0.233
Mill	6	145	Lost.	....	....	....	....
Diffusion	7	146	5.79	0.519	—0.294	3.248	—1.833
Mill	8	154	11.42	0.485	—0.190	3.031	—1.187
Diffusion	9	155	6.47	0.579	—0.071	3.618	—0.444
Mill	10	162	10.17	0.438	+0.075	2.740	+0.534
Diffusion	11	163	6.75	0.557	—0.134	3.481	—0.841

AFTER SECOND CARBONATATION.

Character of juice.	Experimental number.	Serial number.	Per cent. sucrose.	Nitrogen per 100 of sucrose.	Increase or decrease in percentage of nitrogen.	Albuminoids, per 100 of sucrose.	Increase or decrease in percentage of albuminoids.
Diffusion	3	85	....	....	....	....	....
Mill	6	145	8.90	0.382	+0.012	2.387	....
Diffusion	7	146	5.49	0.559	—0.254	3.494	+0.246
Mill	8	154	8.71	0.547	—0.128	3.419	+0.388
Diffusion	9	155	6.20	0.585	—0.065	3.631	+0.013
Mill	10	162	12.05	0.539	+0.186	3.371	+1.031
Diffusion	11	163	6.56	0.571	—0.120	3.572	+0.091

EXTRACTION OF SUGAR FROM CANE.

This problem has been discussed in a special report already published.*

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* The Process of Diffusion Applied to Sorghum Cane. Chem. Div. Dept. Ag. Bulletin, No. 2.

A MORE COMPLETE SEPARATION OF THE SUGAR FROM THE MOLASSES.

My experiments in this direction are just beginning, but I think I can outline their scope.

As is well known, sugar combines with the oxides or hydrates of the alkaline earths, viz, barium, strontium, and lime, to form sucrates which are insoluble in an aqueous solution of sugar.

Taking advantage of this principle, beet-sugar chemists have been working for several years to secure a separation of the sugar from the molasses as a sucrate of one of these bases. I have proposed to do the same thing with sorghum molasses, and my experiments are now in progress. In the sorghum molasses, however, the problem is a more difficult one than with that from beets.

The invertose and anoptose present in such large quantities are liable to be attacked by the base, so that the whole operation has to be conducted at a low temperature. I cannot yet hazard any prediction as to the success with which my experiments may meet. I have already gone far enough to corroborate the results lately obtained by the German chemists showing that sucrose can be almost completely precipitated by lime in the cold.

I shall continue my work in this direction until I determine the value or worthlessness of the lime process in the extraction of sucrose from sorghum molasses, and its effects on the other sugars present.

UTILIZATION OF BY-PRODUCTS.

The by-products of the sorghum sugar manufacture are, (1) the seed, (2) the blades, (3) the bagasse or diffusion chips, (4) the scums and subsidence products, (5) the molasses.

The sorghum plant is a true cereal. The seeds have starch, albumenoids, oil, sugar, and fiber in such proportions as render them suitable for animal food. The following analyses of the seed, compared with those of wheat, corn, and buckwheat, will show the place which the sorghum holds among the more prominent cereals:

Table of comparative analyses of sorghum seed.

Cereals.	Per cent. water.	Per cent. ash.	Per cent. fat.	Per cent. nitrogen free extract.	Per cent. crude fiber.	Per cent. albumenoids.	No. of analyses.
Wheat	10.27	1.84	2.16	71.98	1.80	11.95	260
Corn	10.04	1.52	5.20	70.69	2.09	10.46	114
Sorghum	13.10	1.80	3.60	70.80	2.00	8.70	*11
Buckwheat	12.60	2.00	2.20	64.50	8.70	10.00	*8

*Armsby's Farmers Annual.

The importance of this by-product will be more apparent when it is remembered that for each ton of ripe canes about 125 pounds of seed will be produced.

From one acre producing 10 tons of cane 1,250 pounds of seed can be obtained.

If this is compared with the average production of wheat and corn, the following table results:

Average number pounds wheat per acre	720
Average number pounds corn per acre	1,456
Pounds sorghum seed, at 10 tons per acre	1,250

It thus appears that the custom of many farmers which allows the seed to rot on the ground is wasteful in the extreme. In the one item of seed alone the sorghum cane possesses a by-product which is more valuable than the by-products of all other sugar-producing plants combined.

THE BLADES.

The dried blades of sorghum make an excellent fodder.

The following analysis, taken from the Agricultural Report of 1879, page 57, shows the constitution of sorgum blades after complete drying:

Analyses of sorghum and sugar-corn blades.

Varieties.	Weight fresh.	Weight dry.	Acid and color.	Wax, per cent.	Resin, per cent.	Sugars, per cent.	Gum, per cent.	Starch isomers, per cent.	Albumenoids, per cent.	Alkali extract, per cent.	Crude fiber, per cent.	Ash, per cent.
Sugar corn....	380	116. 6	1. 48	0. 54	5. 20	8. 21	4. 54	24. 77	11. 34	12. 65	20. 83	10. 44
Honduras sorghum.	1428	285. 3	3. 29	1. 67	6. 67	9. 37	2. 78	21. 22	10. 43	11. 98	18. 51	14. 08
Early Amber sorghum.	399	97. 7	1. 46	5. 05	7. 91	8. 58	3. 82	14. 49	13. 14	12. 08	17. 98	15. 49

The above percentages are all given for the dry blades.

The blades are generally left on the stalks in working on a large scale, and hence any value they may have must be looked for in the bagasse or diffusion chips.

THE BAGASSE AND DIFFUSION CHIPS.

These still contain nutritive matter, but are mostly cellulose. I doubt whether they could be utilized for feeding purposes. When dried they make excellent fuel, and the bagasse is used in many places for that purpose.

They also make good bedding for animals, and thus are returned to the soil in the form of a good manure. This utilization, I think, is the most promising from an economical point of view.

Experiments have also been made with them in the manufacture of paper pulp. These have been fairly successful and are deserving of further prosecution.

THE SCUMS AND SUBSIDENCE PRODUCTS.

The scums are rich in albuminoids, and with the precipitates, containing lime, phosphoric acid, &c., make a valuable fertilizer.

Their composition is shown in the following table, taken from the Agricultural Report, 1880, page 134.

Constituents.	Lime and clay precipitate.	Lime precipitate.	Scum.
Moisture	9.77	7.69	5.72
Mineral matter	21.69	7.00	14.30
Chlorophyl and wax	17.60	8.95	14.44
Sugars	10.80	43.96	15.06
Resins	3.61	3.26	5.08
Gums	6.02	11.40	11.10
Albuminoids	25.58	4.55	8.05
Undetermined	5.73	12.71	5.58
Crude fiber	2.20	0.48	5.49
Starch isomers	Trace.	Trace.	15.18

These substances vary greatly in their composition, according to the kind of defecation practised.

The scums and precipitates should be dried by exposure on a cement floor to the action of the sun's rays.

The dry residue is ground to a fine powder and applied like ordinary commercial fertilizers.

MOLASSES.

There is still another factor in the sorghum problem which must not be left without attention. If the production of sugar from sorghum should prove profitable, it is certain that the industry will rapidly spread, and the production of sugar increase until it equals the demand of the country. The history of the progress of the beet-sugar industry in France and Germany teaches us that this will be the event which is certain to occur. When this happens the product of molasses will be enormous, far greater than the demand of ordinary consumption will dispose of. On account of the large percentage of uncrystallizable sugar which the sorghum juices now contain, the yield of molasses in the manufacture will be far greater than with the cane of the tropics or the beet of the temperate zones.

As I have already shown, the proportion of uncrystallizable to crystallizable sugar in the sorghum juice is about one to three. This sugar prevents nearly an equal weight of sucrose from crystallizing.

By the methods in use at the present time a yield in dry sugar of three-fifths of the total sucrose present in the juice is an exceedingly gratifying one. It follows, therefore, that the weight of molasses produced (including the water) will remain nearly double that of the sugar in the most favorable of the present circumstances. It is idle to suppose that such quantities of molasses can find their use for culinary and table purposes. The only remaining uses to which the molasses can be put are food for animals and distillation. There is little doubt but that the conversion of the sugars in the molasses into alcohol will prove far more profitable than feeding them to stock.

A much greater increase in sorghum production throughout the country will result in the use of molasses on a large scale as a source of alcohol and rum.

PRODUCTION OF ALCOHOL.

I will give an illustration to show the theoretical yield of alcohol in order to furnish data for calculations of the yield on a large scale.

Molasses, after the second or third crystallization, contains about 32 per cent. each of sucrose and non-sucrose, in all 64 per cent of fermentable matter.

Under favorable conditions the sugar present will yield 40 per cent. of its weight as alcohol, or 25 per cent. of the weight of molasses. One gallon of molasses, therefore, weighing 11 pounds, would give 2.75 pounds absolute alcohol and 3.03 pounds 90 per cent. alcohol. Thus each gallon of molasses would give nearly half a gallon of commercial alcohol.

Alcohol can also be obtained from the juice of the cane, as the following experiment in fermentation will show:

FERMENTATION OF THE JUICE.

One-half car of sorghum juice, defecated by heat alone, was pitched on October 1 with 10 cakes Gaff, Fleischmann & Co.'s pressed yeast and placed in crystallizing room at 40° C. The next day there was a slight fermentation, and the juice had become very acid. The temperature was evidently too high. On October 3 there was a partial blanket of yeast, which, on the next day, was complete, with a violent fermentation; temperature, 33° C; density, 9° B. On October 6 the fermentation had apparently ceased, the car was removed, and the contents distilled. The liquid contained still 4 per cent. of glucose and nearly 1 per cent. of acid. The distilled liquor varied from 20 to 3 per cent. of alcohol. It was redistilled, treated with bone-black and lime, and furnished 4½ litres of alcohol, sp. gr. .9477, 23° C., and 3½ litres .9855, 23° C.

The original juice amounted to 21 gallons, or 80 litres, from which about 1.8 litres of absolute alcohol was obtained, or 2.05 per cent., and this under very unfavorable circumstances of fermentation and distillation. The original juice, it may be added, contained about 13 per cent. of total sugars, which would yield theoretically 5.5 per cent. of the weight of juice in alcohol or 4.4 litres. The yield was therefore less than half of theory.

I hope that by means of barium, strontium, or lime the contents of sucrose in sorghum molasses may be greatly reduced, but from the nature of the plant there will always be a large production of molasses even if the sucrose be entirely separated.

The distillery and sugar factory will naturally fall together when the industry grows to a sufficient magnitude, as they have already done in Europe.*

I am led to believe, from a careful study of the preceding investigations, that the northern sugar industry is yet far from being established on a basis of economic success. Of the two chief sources of northern sugar the beet appears to have the advantage over the sorghum plant, and I shall not be surprised to find its successful culture inaugurated in localities suitable to its growth before all the conditions upon which profitable sorghum-sugar growing depends shall have been established. It is not to be inferred that any partiality has been shown sorghum in the investigations which I now transmit to you, because nearly the whole of the matter is derived from researches on the sorghum plant. This has arisen because the division of which I have charge was especially engaged in the line of research, and from the fact that the conditions which afford success to beet culture and sugar manufacture have already been well established by European investigations, while many of the chief problems connected with sorghum culture are still almost untouched.

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* Since the alcohol made from molasses is scarcely suitable for a beverage, but is fit only for use in the arts, it would prove a great encouragement to the sorghum and sugar beat industries to allow its distillation free of tax.

ISOTHERMAL CHARTS.

The following charts have been prepared for this report by the Signal Office of the U. S. Army. I desire to thank General Hazen and his assistants for the valuable services they have so freely given.

First are given charts of the mean temperature of the several months from March to November. Isotherms, which promise to be of peculiar interest in the sorghum industry, are marked in heavier lines. The careful student of the sugar industry will be struck with the irregularity of these lines, and especially as they approach the Pacific coast.

The great deflection southward, caused by the Eastern mountain ranges, will also be carefully noted.

Following the charts for the several months is found one which gives the mean summer temperature for the three months of June, July, and August. By almost unanimous consent, those who are interested in sorghum as a sugar-producing plant have assigned the isotherm of 70° F. for the summer as the northern limit of successful sorghum culture, while the growers of the sugar-beet look for their greatest success north of that line. The track of this line, therefore, across the continent will be traced with interest. It will be seen that the great corn-producing regions of the Northwest lie almost wholly south of this line. Its direction from West Virginia due north almost to Buffalo is a very striking peculiarity of its course. In most seasons sorghum in some of its varieties can be grown to maturity south of this isotherm.

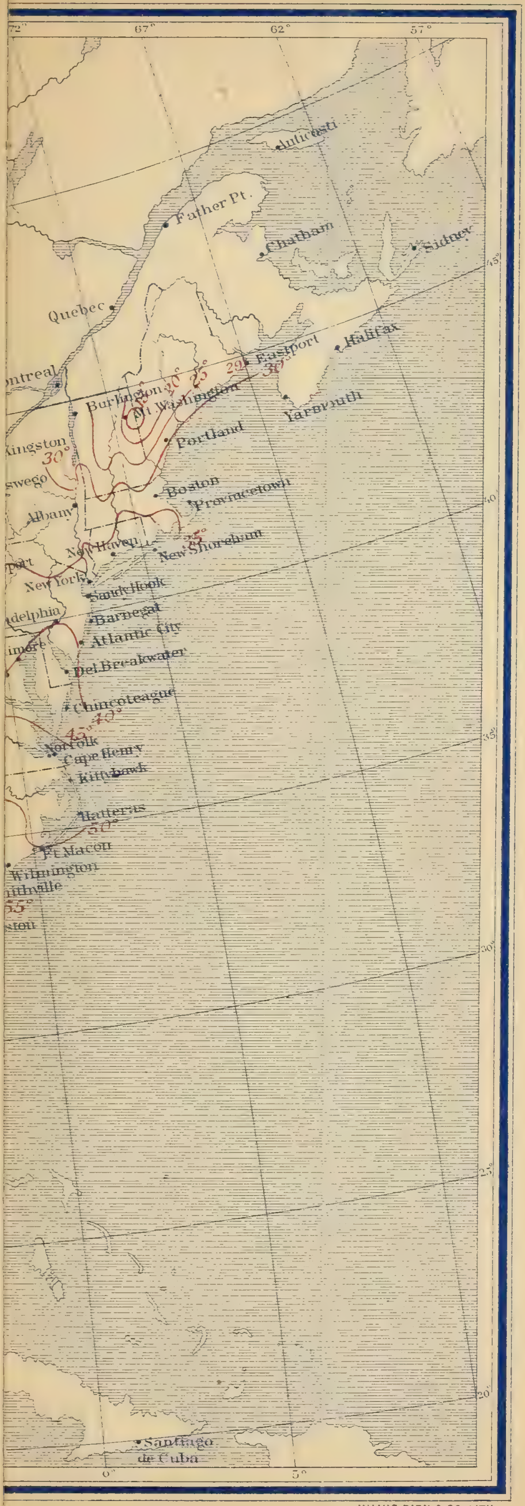
While the isotherm of 70° for the summer months is of greatest interest to sorghum growers, the manufacturer will devote more attention to the lines of 65° for September and 55° for October. The season for manufacture must include these two months, and perhaps also November. The most important line on the November chart is that of 40°.

I should have added one more chart, viz, one showing the mean position of a line constructed from the isotherms of 65° for September, 55° for October, and 40° for November. Such a mean line, in my opinion, would mark out very nearly the northern limit of successful manufacture of sugar from sorghum. Any one interested can get a good idea of the position of this line by studying together the three charts above mentioned.

No attempt has been made in these charts to introduce the question of rainfall. East of Kansas this is not one of great importance. Over limited areas of the corn-producing region the crops are often injured by drought. But generally a sufficient rainfall can be expected for the needs of a plant as hardy as sorghum.

West of central Kansas the question of rainfall is as important as that of temperature. Irrigation is already showing its value in the arid regions of the West, and there are many reasons for expecting to see areas now almost bare of vegetation become valuable sugar plantations under its influence.

A more extended description of the charts is not necessary. Their value will be found chiefly in the method of study by which they are interpreted. This method will depend largely on the local circumstances of the sugar grower and manufacturer.



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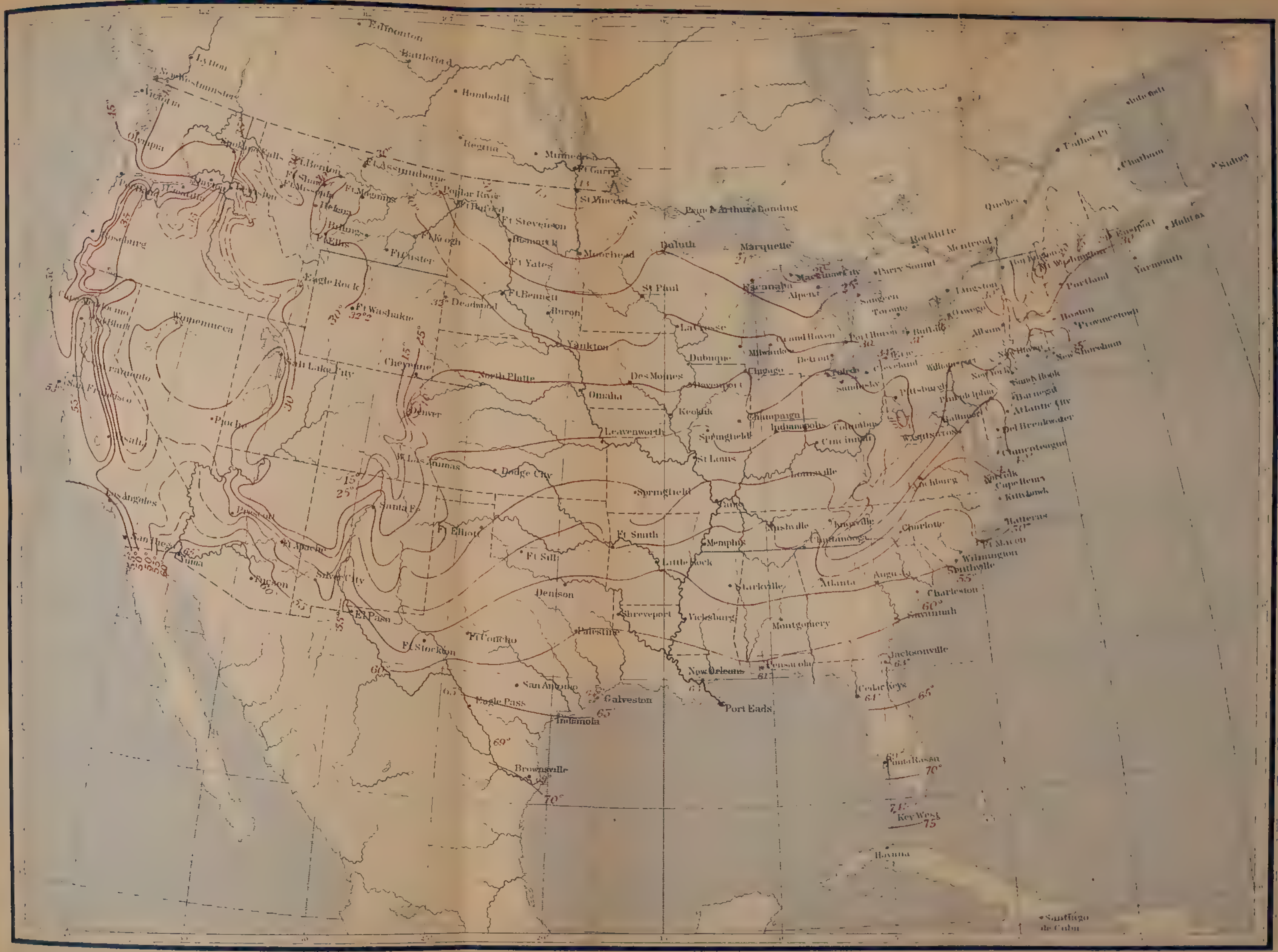
Mean Temperature. March 1870–84.



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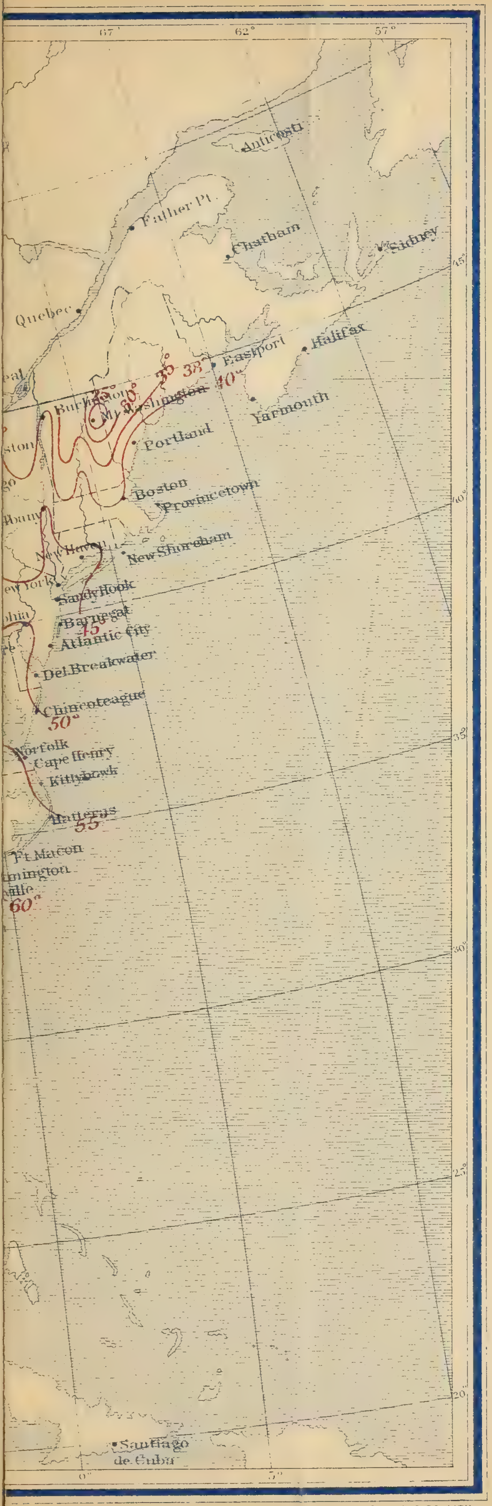

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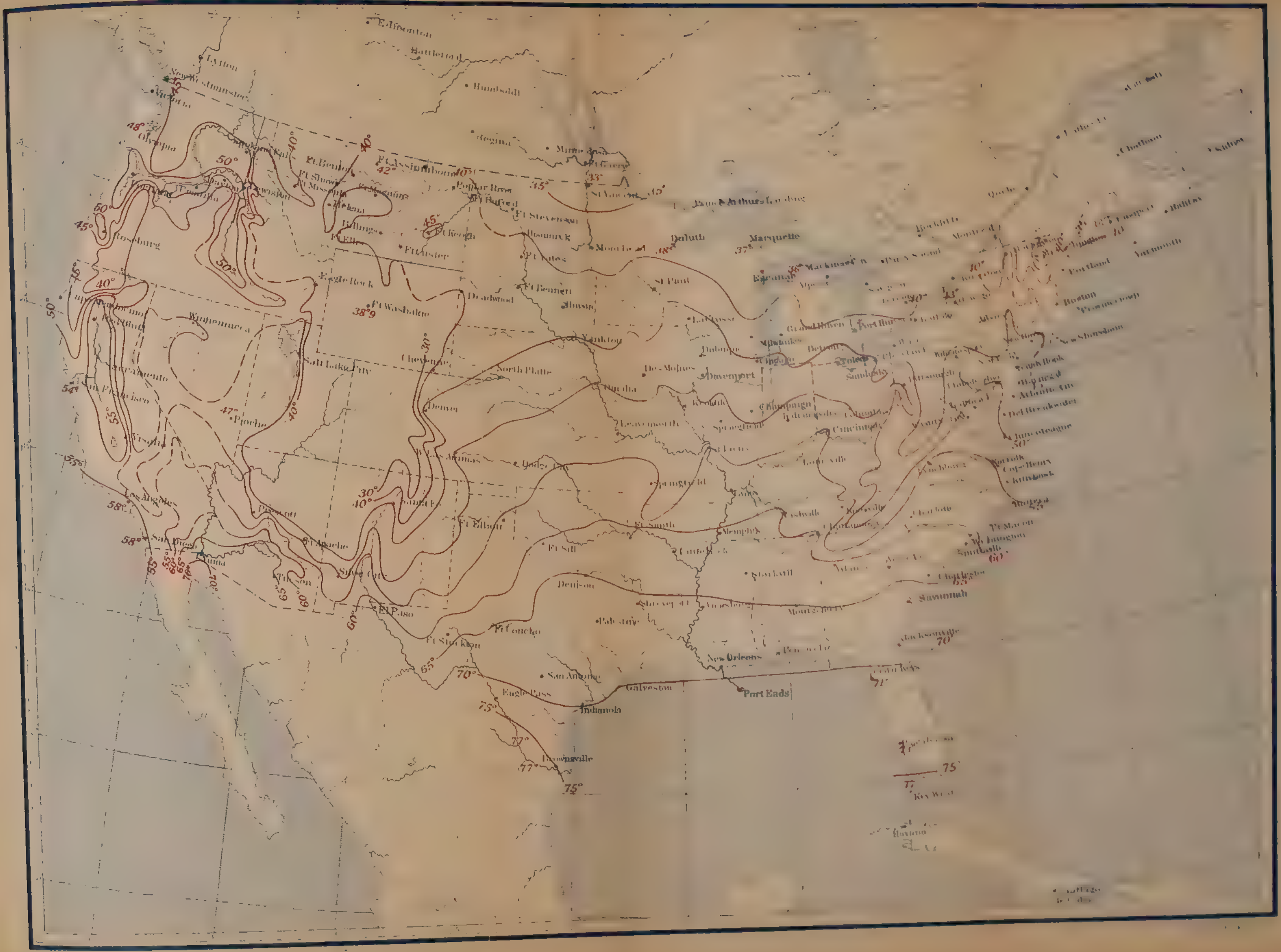
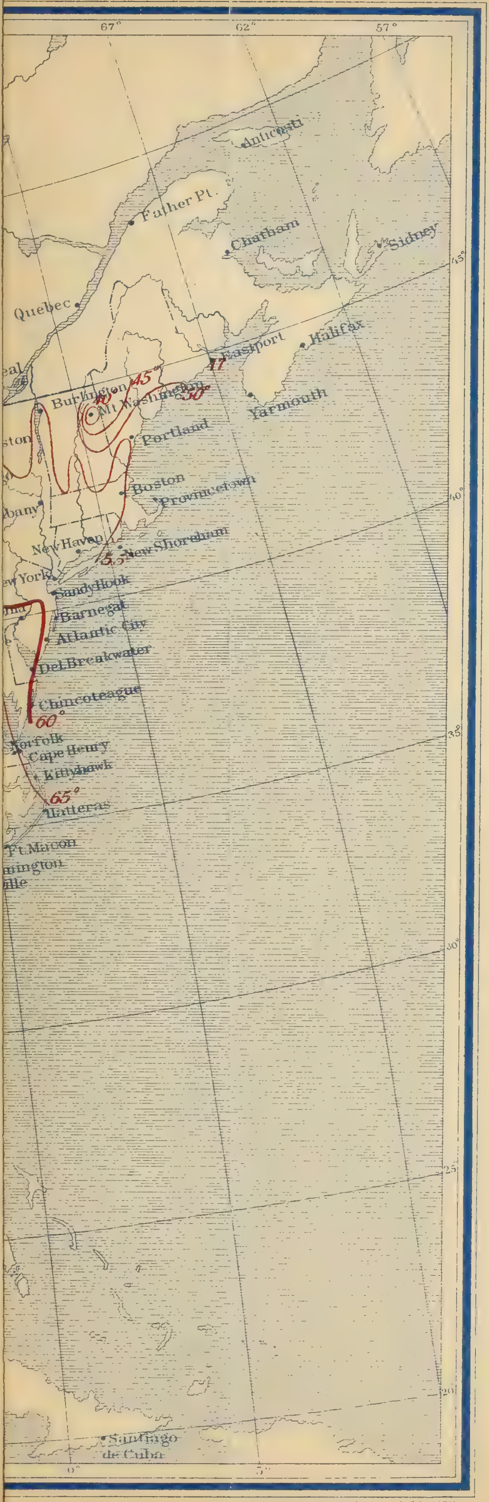
Mean Temperature, April 1870–84.





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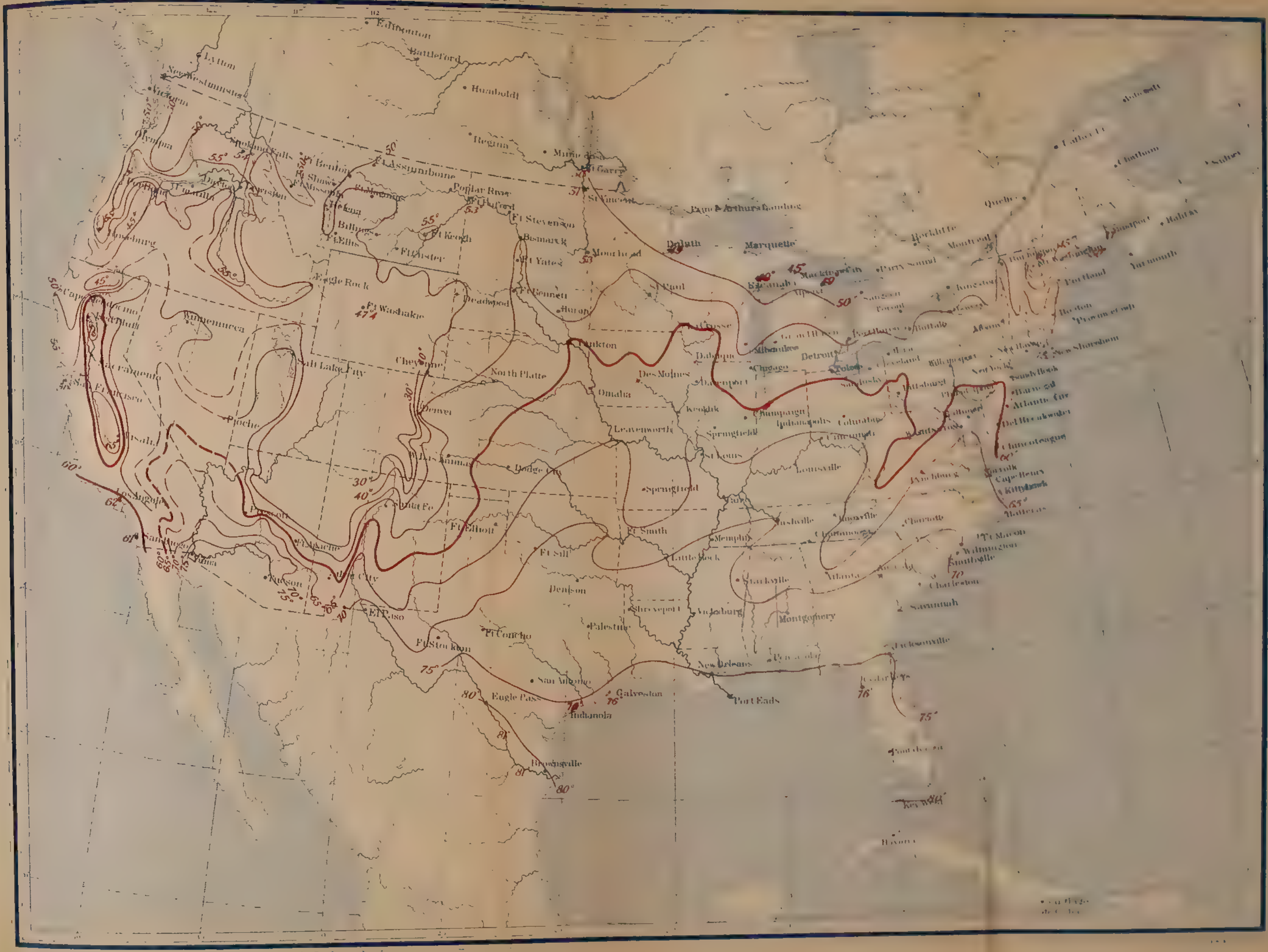
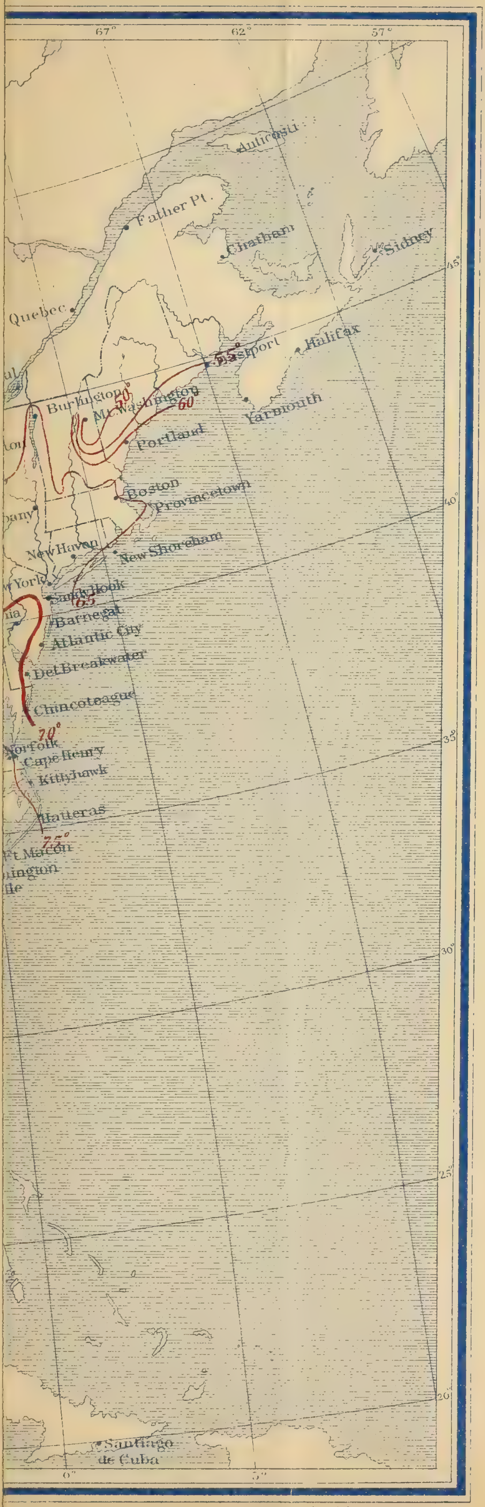
Mean Temperature, May 1870–84.





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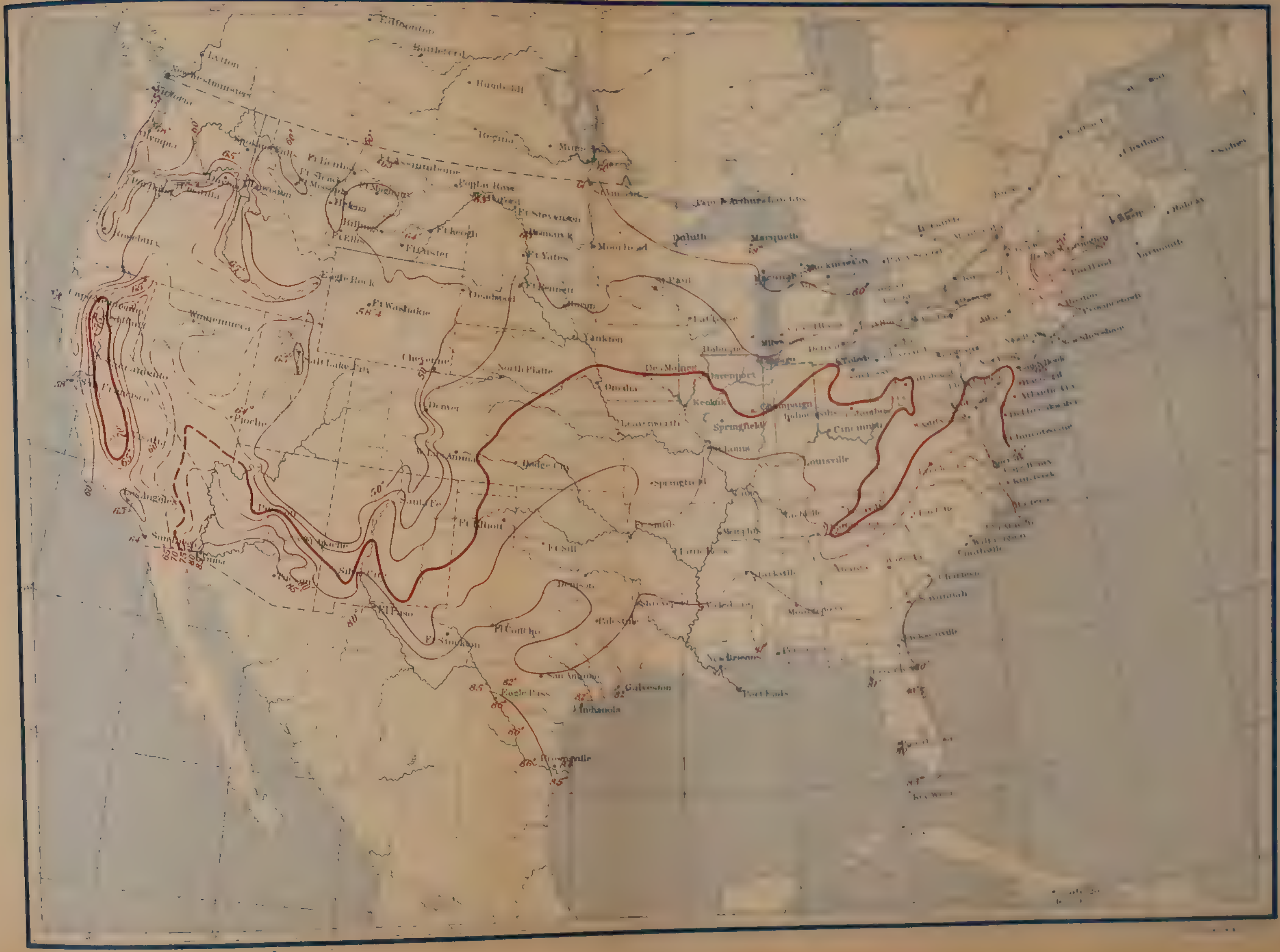
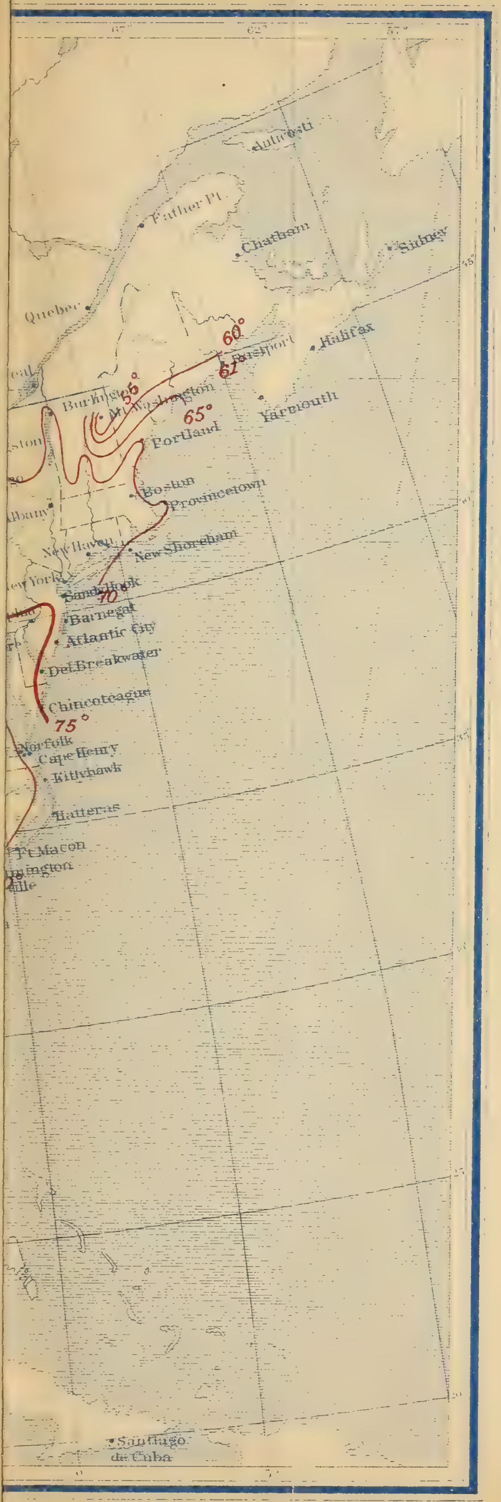
Mean Temperature June 1870–84.





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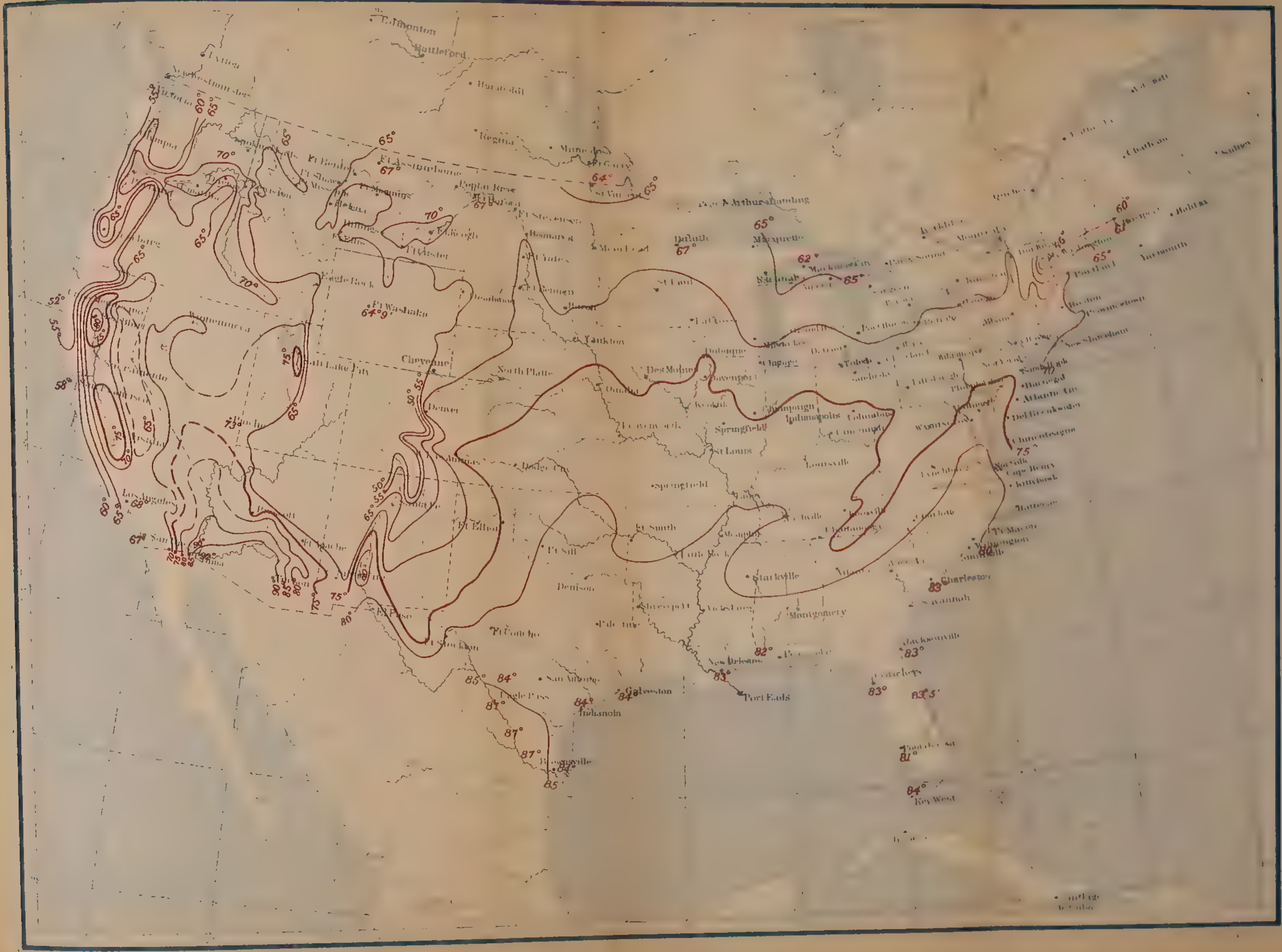
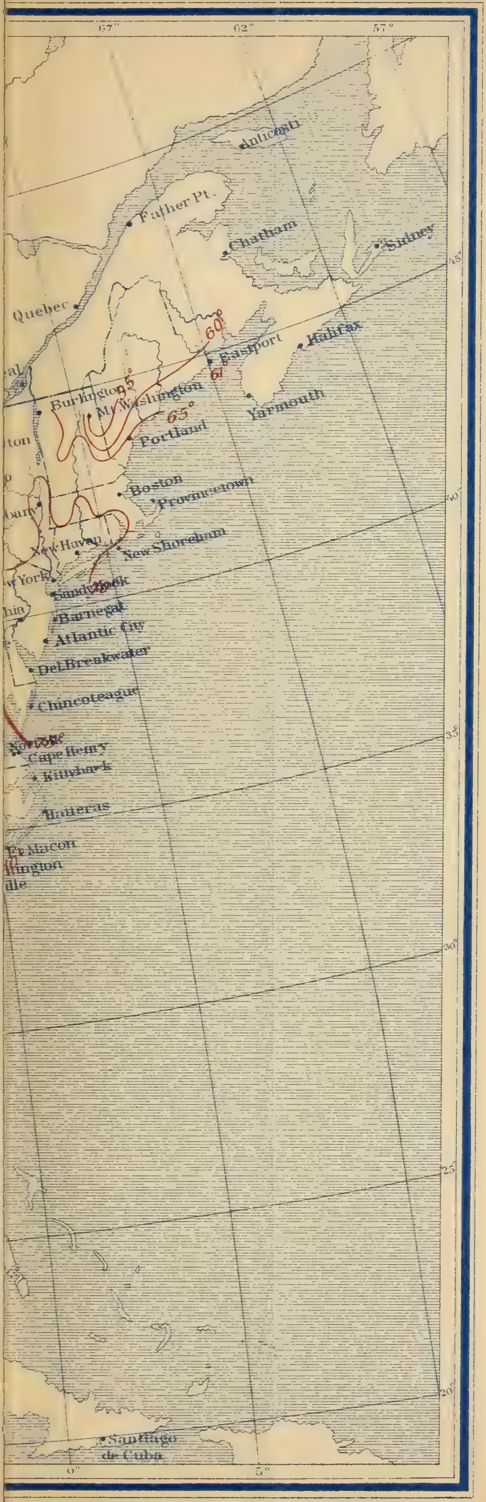
Mean Temperature July 1870–84.





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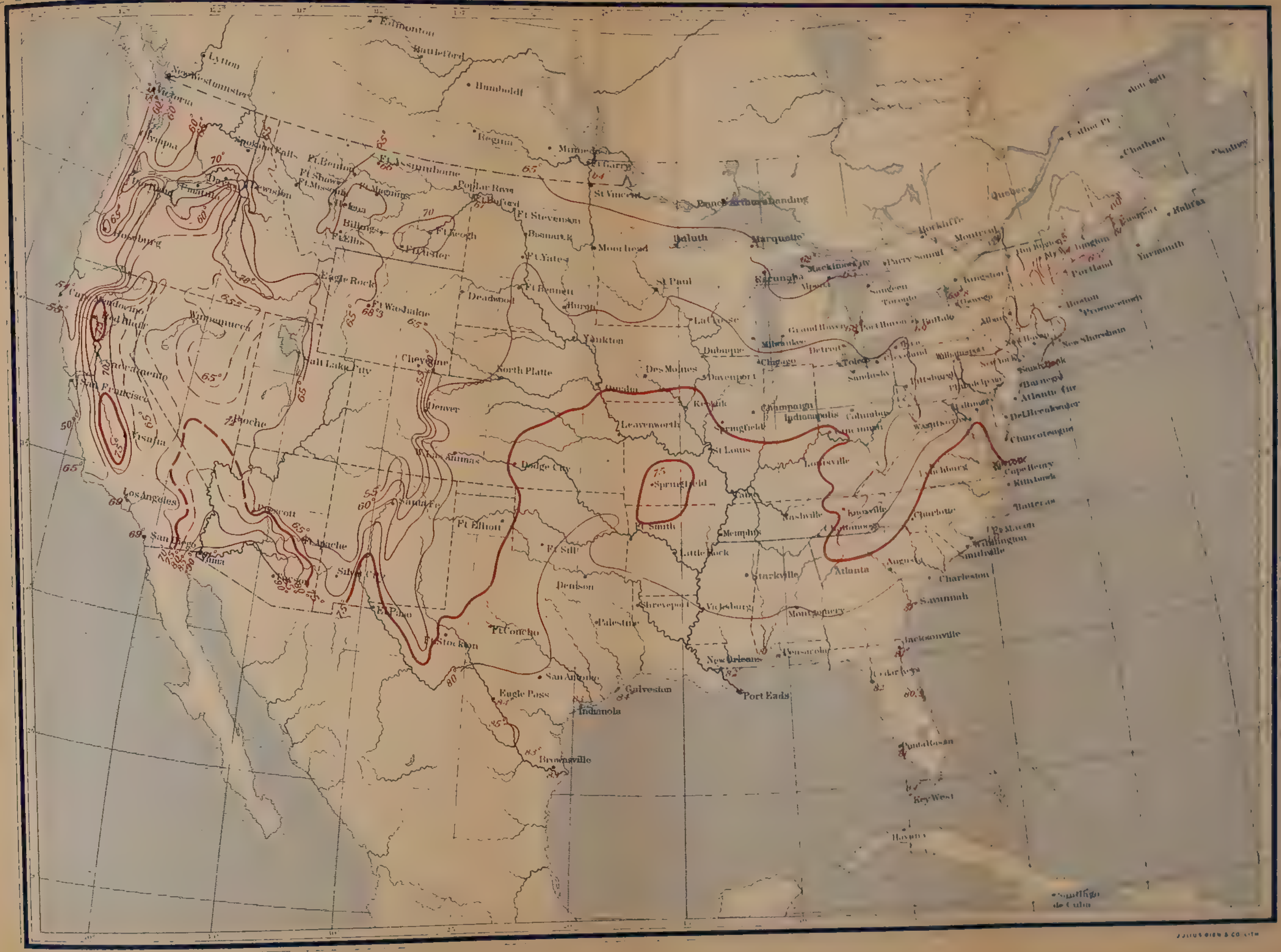
Mean Temperature, August 1870-84.



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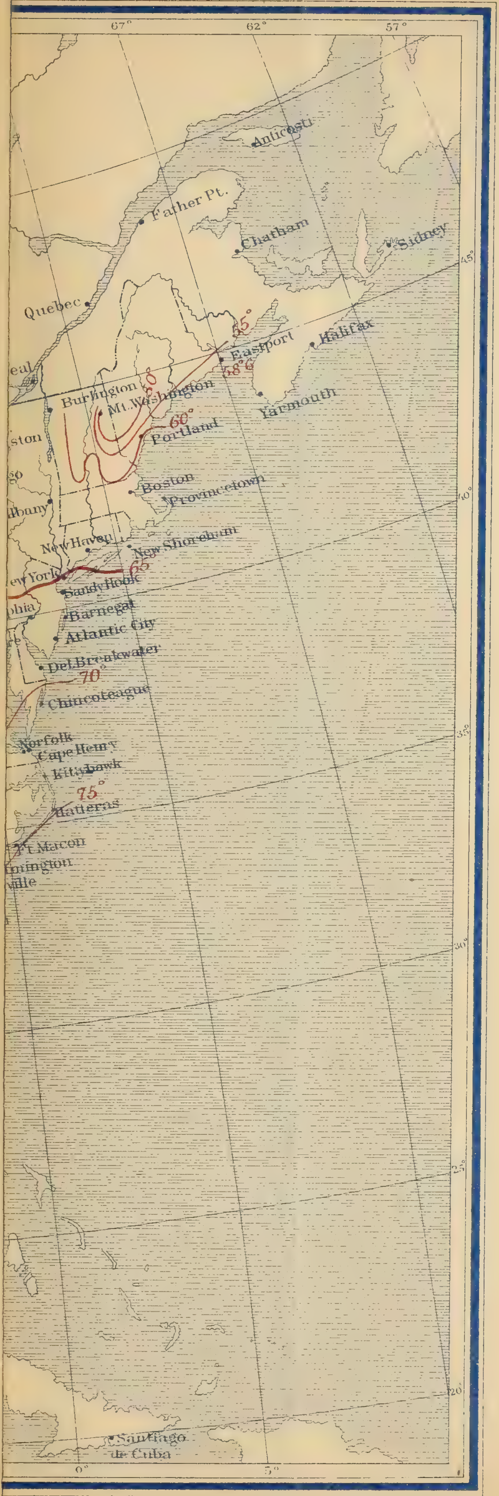

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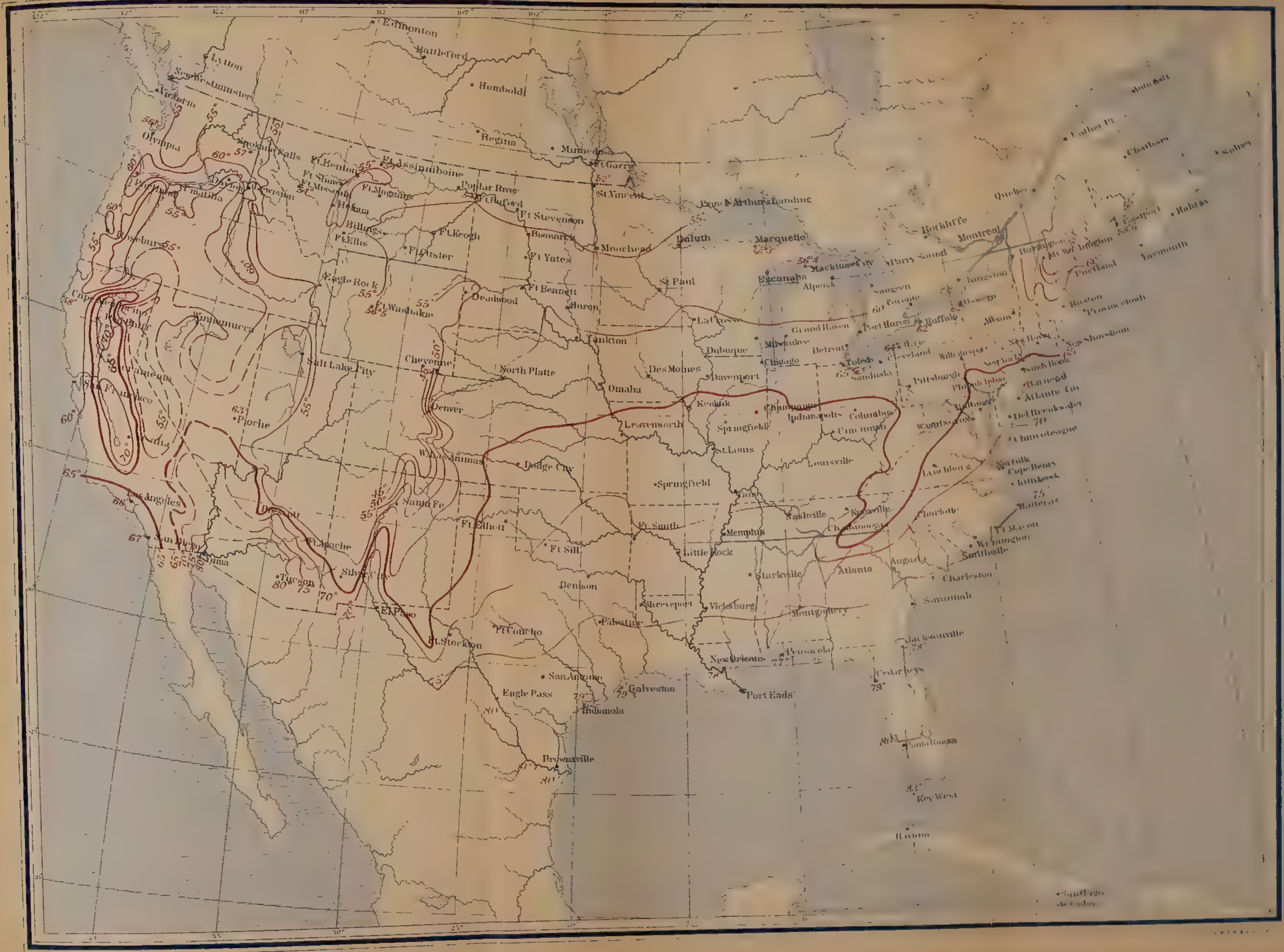
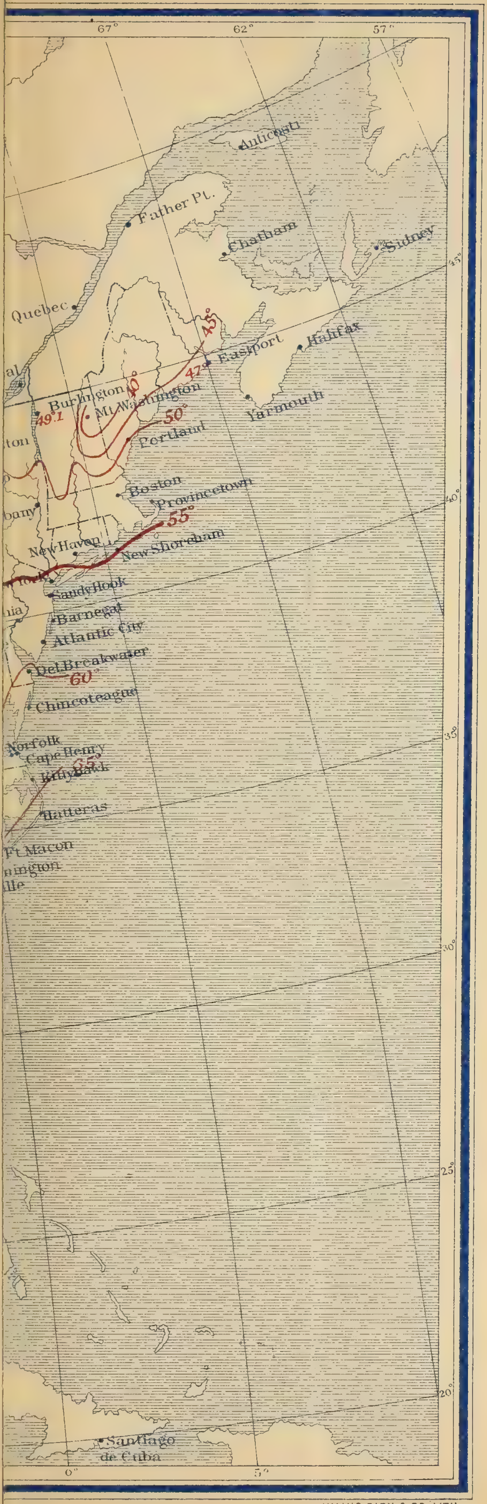
Mean Temperature, September 1870–84.





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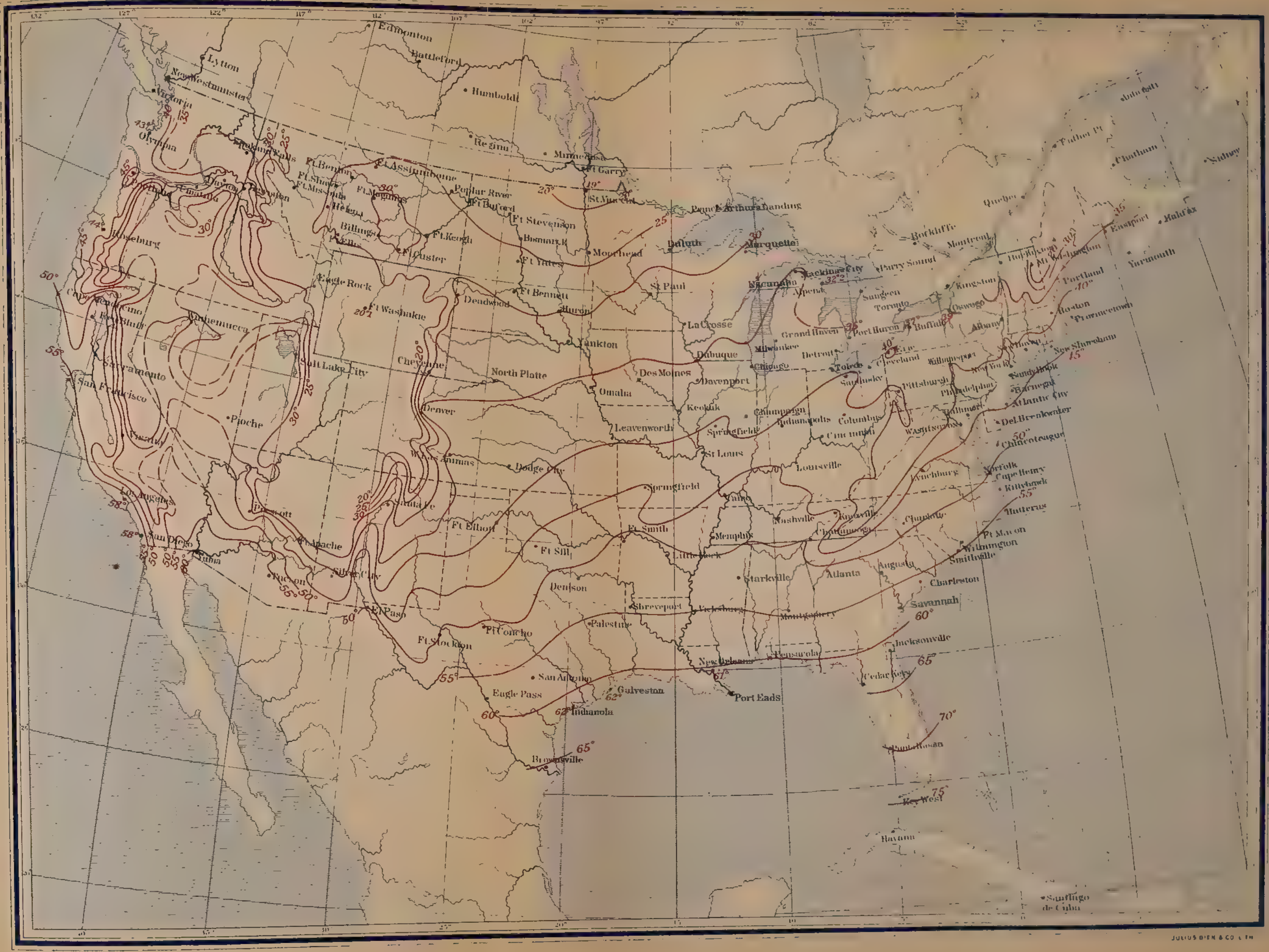
Mean Temperature. November 1870-84.



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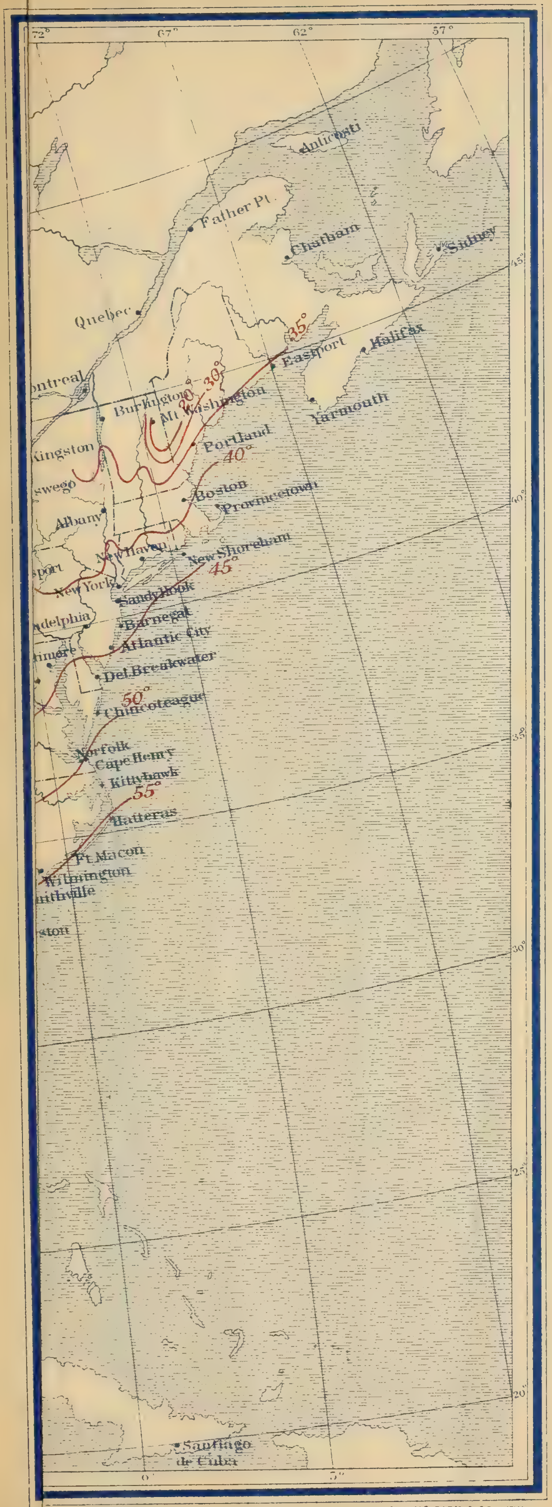

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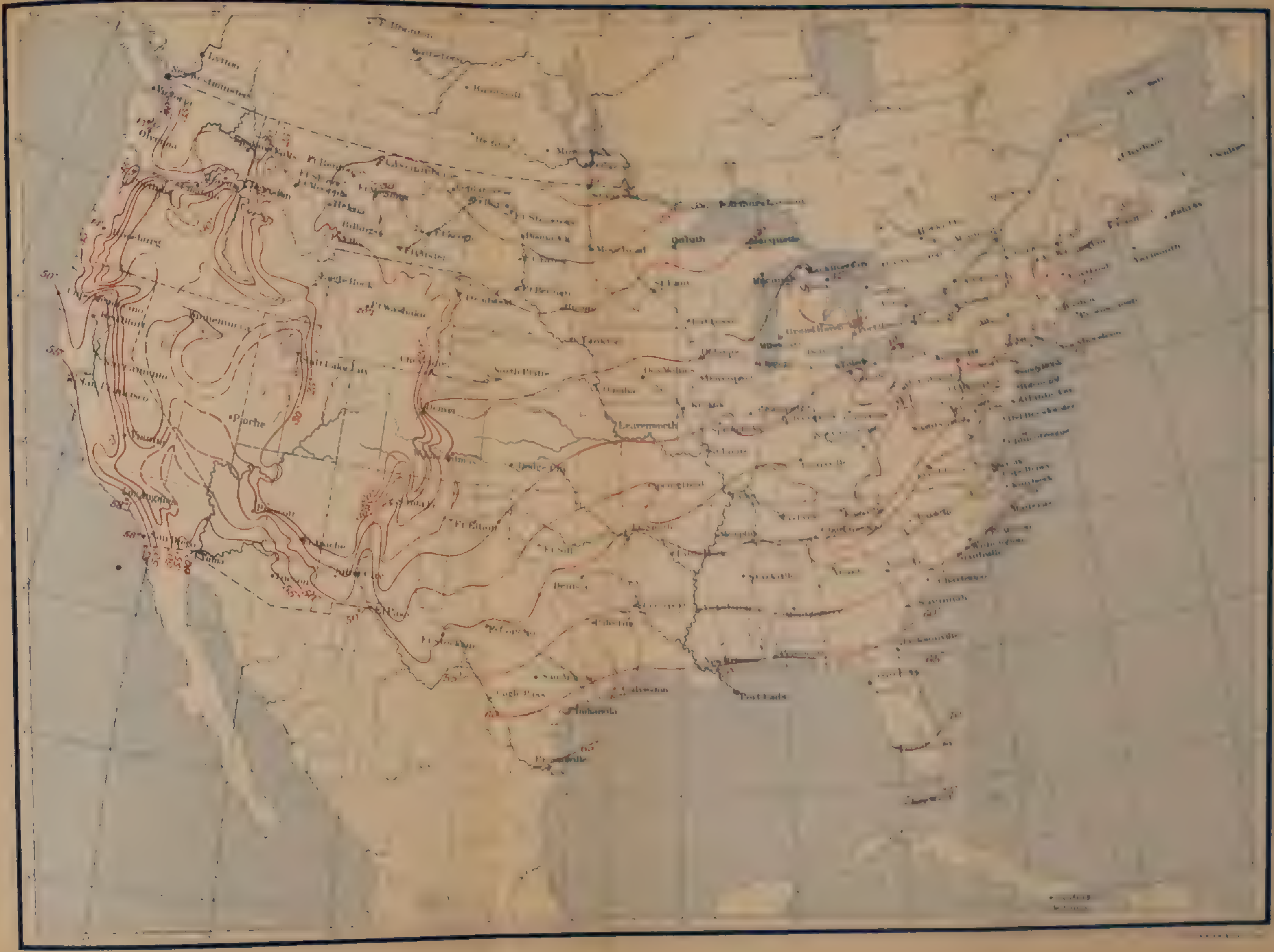
Mean Temperature November 1870-84.



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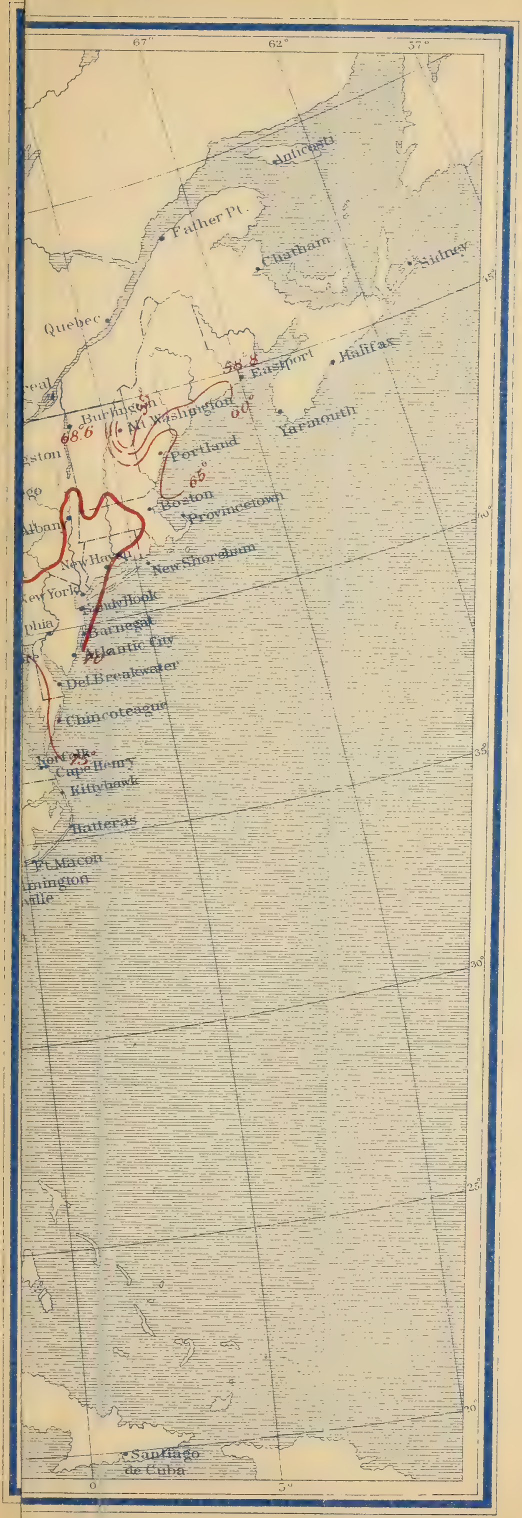

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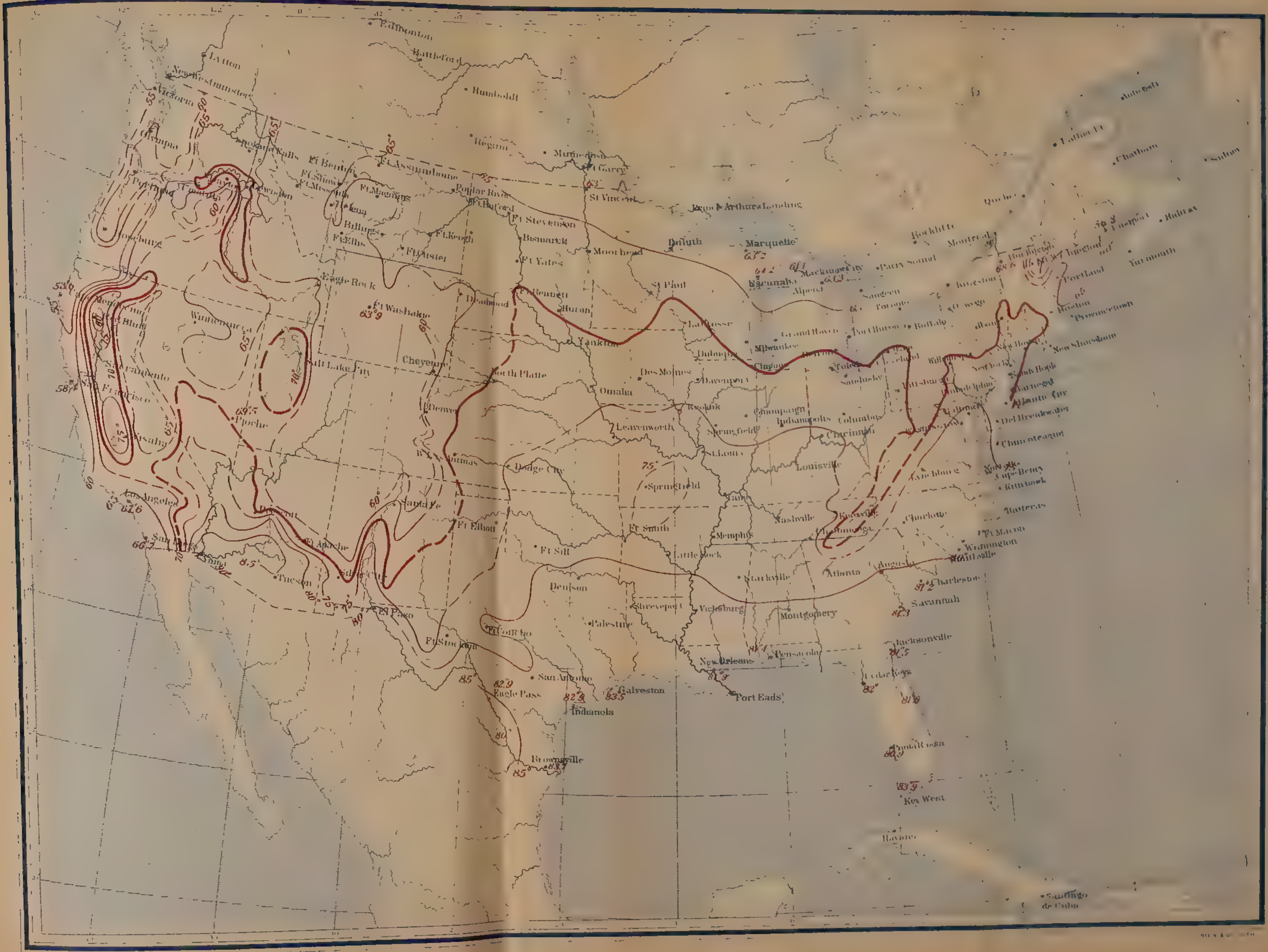
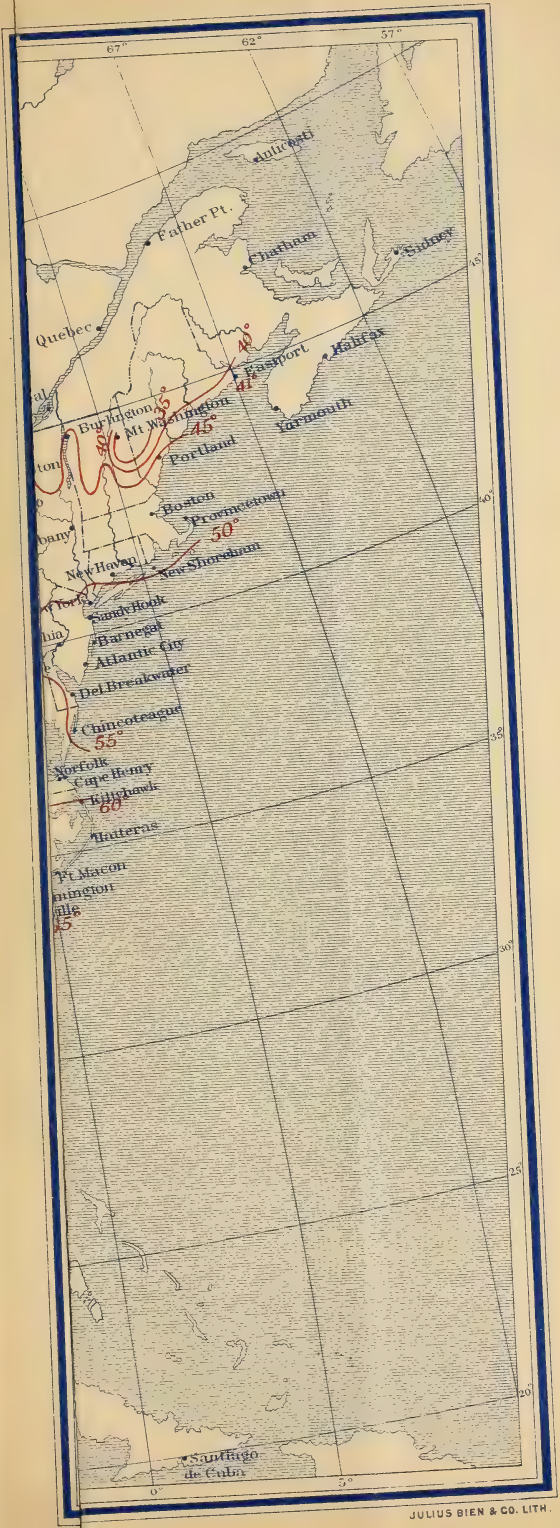
Mean Summer Temperature, June, July and August 1870–84.





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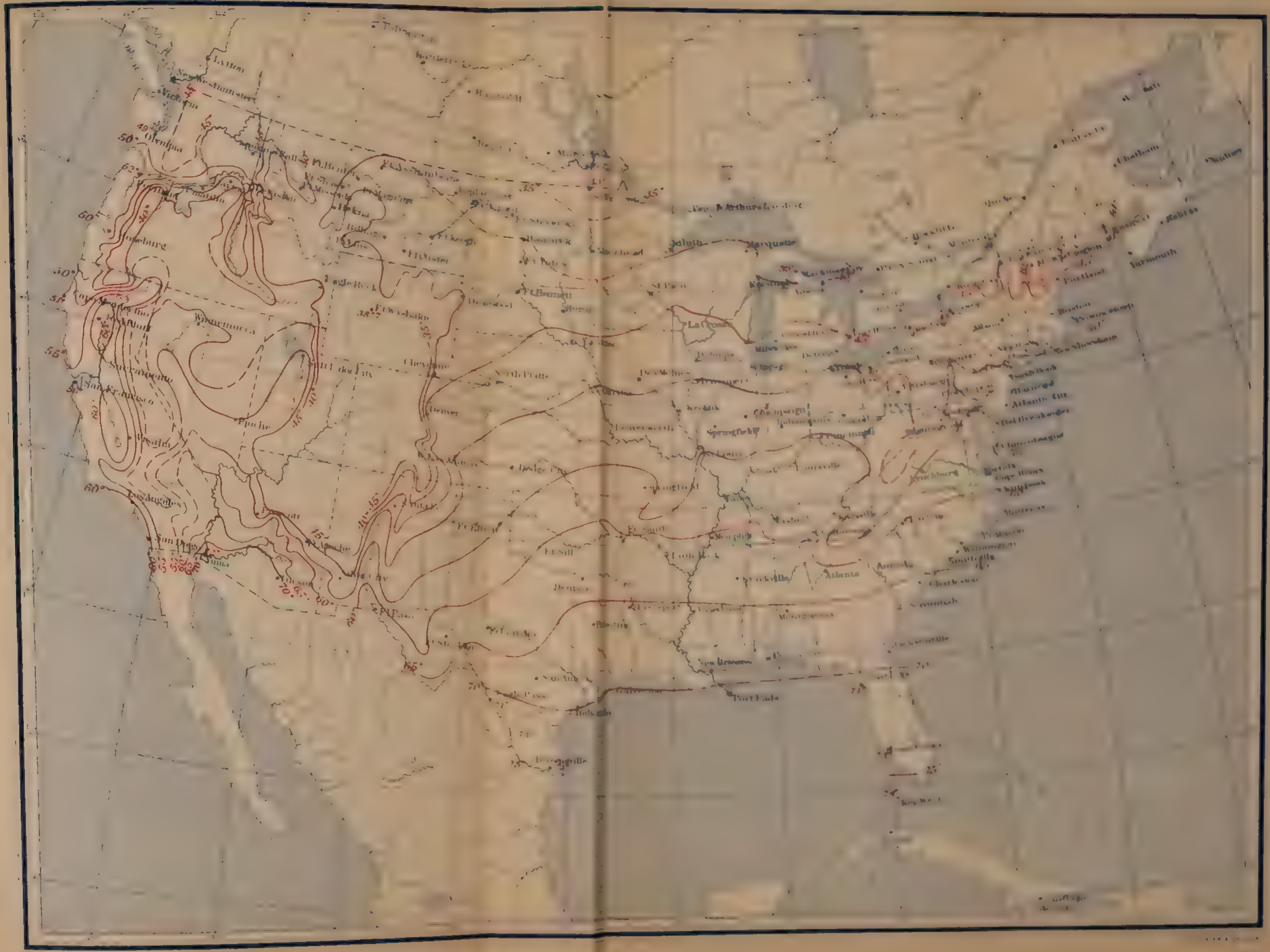
Mean Annual Temperature 1870–84



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